Large Water detector planning for Homestake

3/27/2007

Milind Diwan, Ken Lande

Collaboration

- BNL, UPenn, Berkeley, Princeton, UCLA, Wisconsin, Kansas, Colorado, Catania(Italy)
- Proposal: Written for the Homestake PAC.
- hep-ex/0608023 or BNL-76798-2006-IR

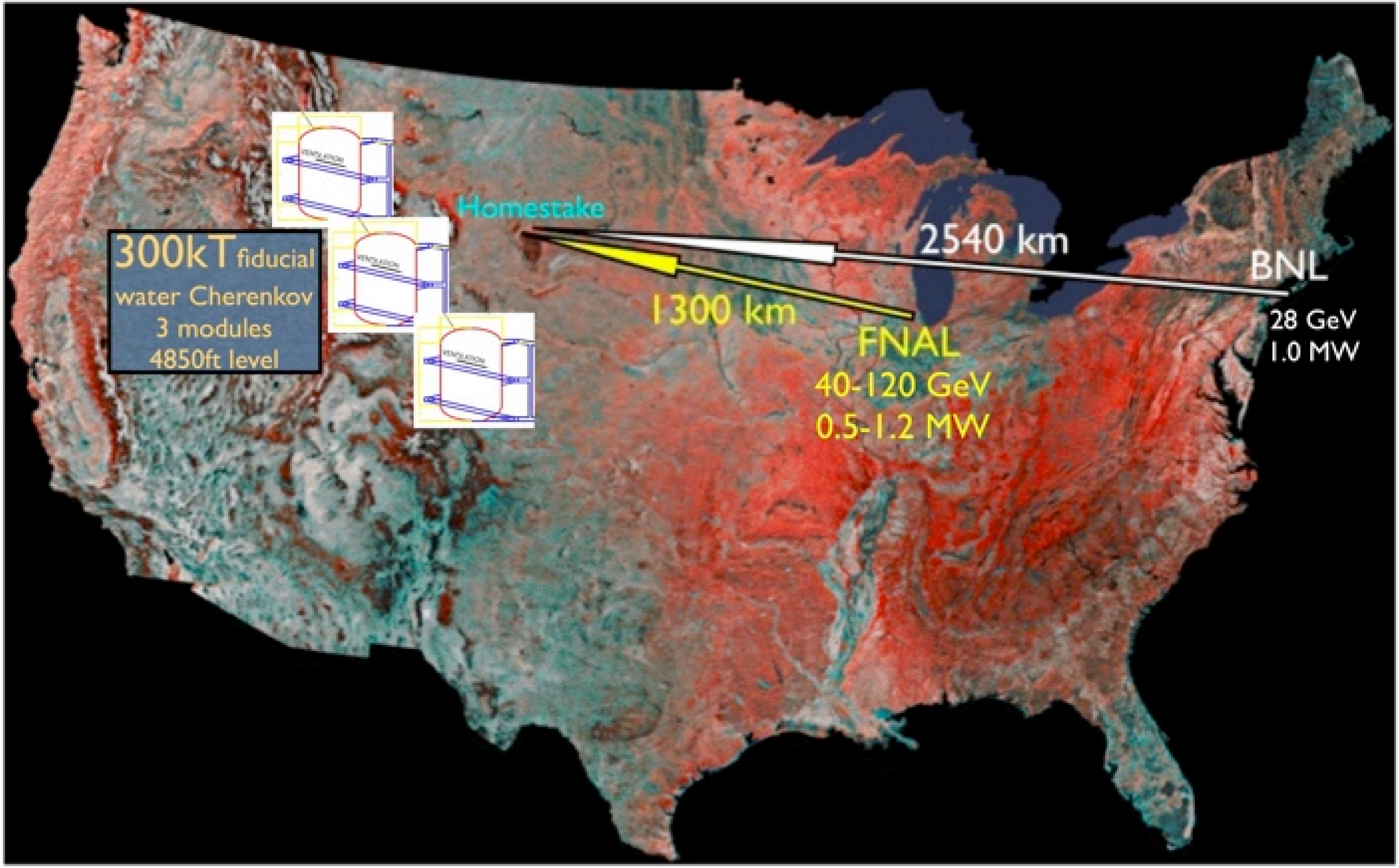
Money ?

- BNL has supported this activity at a level of ~100k/yr for last 5 years.
- Real R&D funding is now needed. Request made to DUSEL R&D. It includes a few other institutions: Columbia, Northwestern.

The plan

- Build a >300 kTon fiducial volume water Cherenkov detector at ~5000 ft depth.
- The detector should have wide dynamic range (5 MeV to 50 GeV)
- Should have good particle identification capability and must lead to a facility with a long life (~30 yrs).

The plan at Homestake



The physics

- Astrophysical sources of neutrinos. In particular, supernova, relic supernova, solar, atmospheric sources.
- Nucleon decay.
- Accelerator neutrino beam with emphasis on CP violation in neutrinos.
- The detector required for all the above has to be very large (~100kton of efficient fiducial mass)

Recent Activities

- US long baseline neutrino experiment study (joint FNAL and BNL effort). Large effort on simulations of detectors and beams. A draft report at http://nwg.phy.bnl.gov/fnal-bnl
- Nusag committee will use above report. Preliminary results report by P. Meyers to HEPAP last Month.
- Talk to the FNAL program committee on Thursday March 29th to report on the joint study. Talk is joint by Diwan/ Rameika.
- Preliminary cost and schedule (Done by C. Butehorn@bnl.gov)
- Subcontract to RESPEC to examine civil construction for 300 kT.
- Subcontract to Bortoszek for detector design.
- Start of detector R&D. PMT pressure tests under progress.
- Water system R&D to reduce costs.

3 elements of detector project

- Cavern excavation
  - Critical for determining size and feasibility
- Photo-multiplier tube production
  - Critical for schedule
- Photo-multiplier installation
  - Drives the technical manpower need.

Backup information

- Rely on SuperK for schedule development
- Rely on SNO for electronics and installation costs.
- PMT cost and schedule information from photonis and Hamamatsu (no actual quotes)
- Information from AUGER on PMT costs.
- Installation details in progress

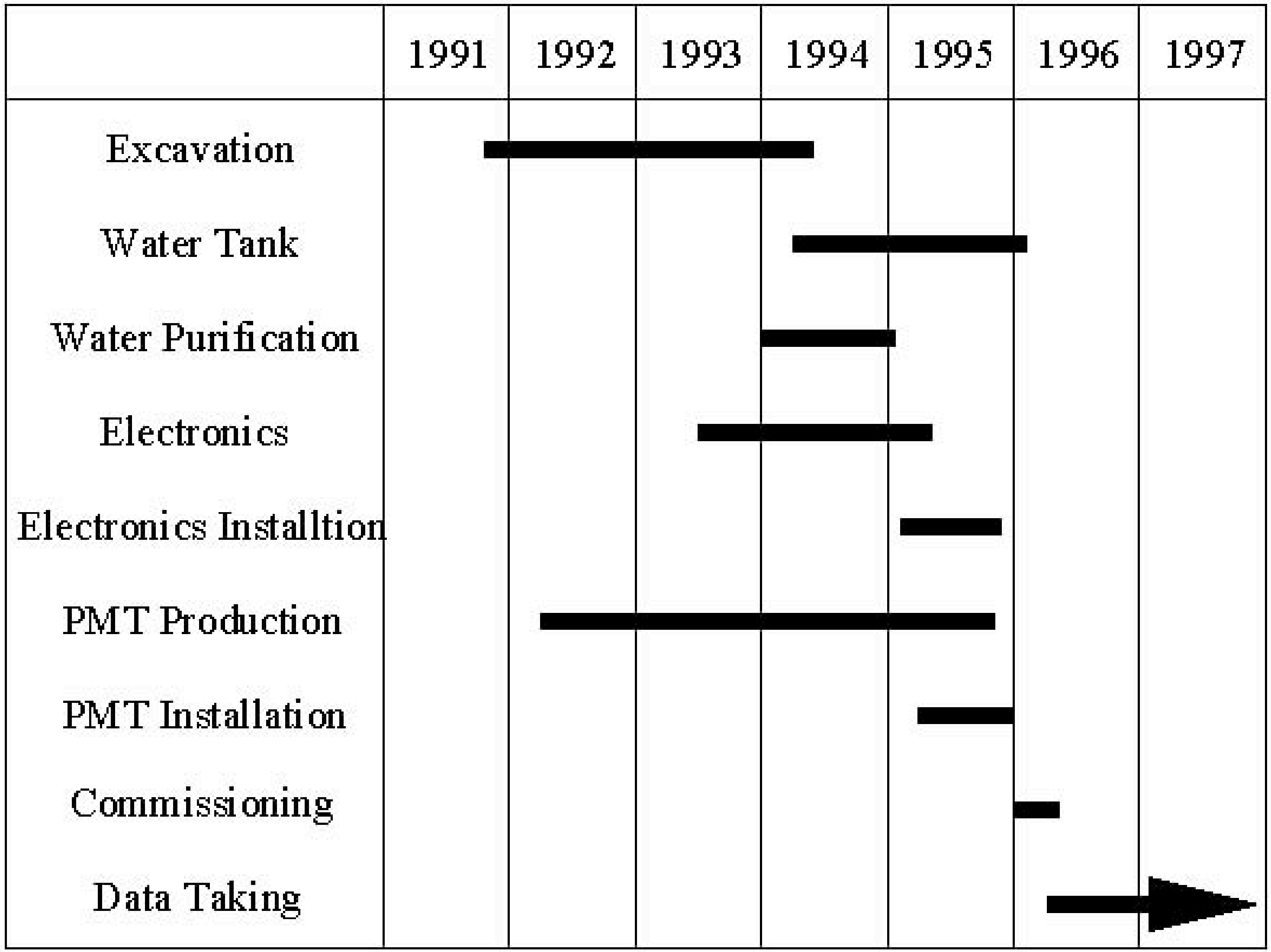


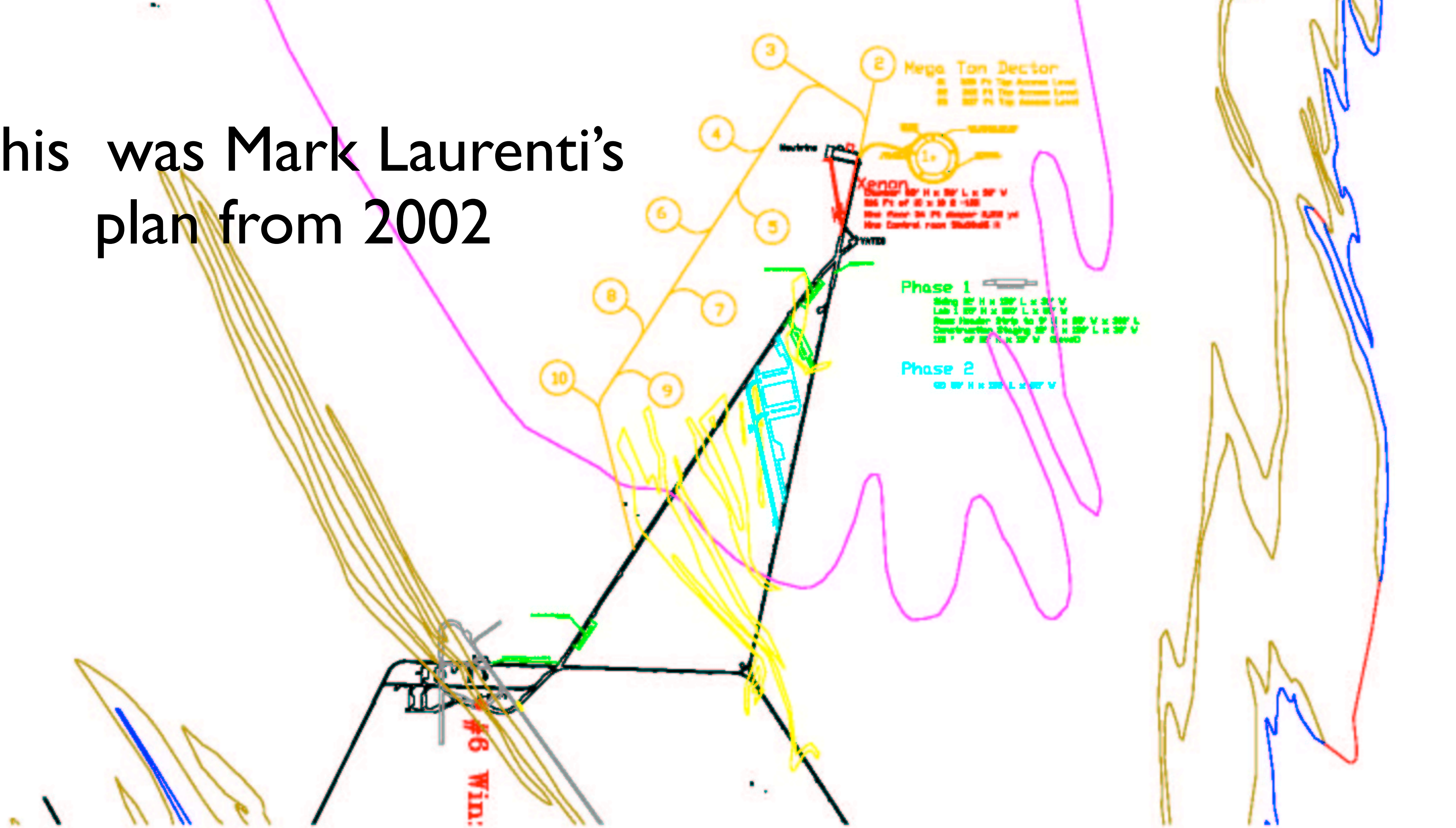
Fig. 3. Super-Kamiokande construction schedule.

Summary cost ($FY07) for 300kT

Cavity construction (30% contingency)	$78.9M
PMT+electronics	$171.3M
Installation+testing	$35.7M
R&D, Water, DAQ, etc.	$8.2M
Contingency(non-civil)	$50.8M
Total	$344.9M

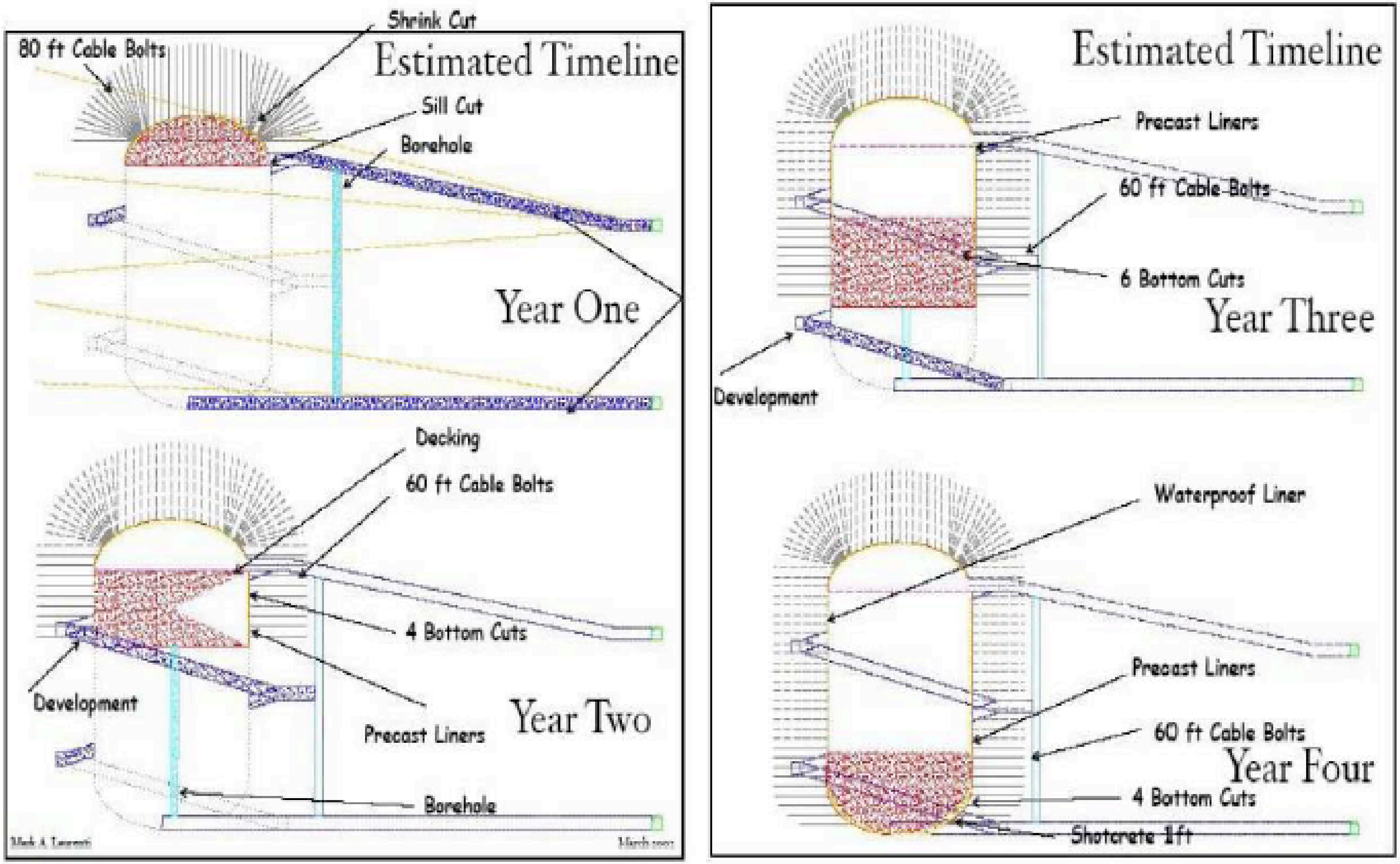
Chamber construction must be estimated for a specific place. Choice here is the 4850ft level at Homestake near the Davis cavern.

This was Mark Laurenti's plan from 2002



Cavern Construction Timeline

Mark Laurenti, Chief Mine Engineer for Homestake till 2001



Chamber excavation

Labor/Benefits	$19.3M
Mining equipment operations	$4.55M
Supplies	$15.8M
Precast concrete liner	$11.4M
Outside contractor (bore holes)	$0.42M
Plastic liner	$0.79M
Rock removal	$3.18M
Mining equiment	$5.30M
Contingency	$18.2M
Total for 3 chambers	$78.9M

Sanity check: estimate based on former Homestake mine chief engineer's estimate. Cost comes out to be $63/ton, well above to historical costs at Homestake.

RESPEC review

- RESPEC has sent us a preliminary review of the excavation cost and schedule. Topical report RSI-1919.

Table 1. Comparison of Cost Per Unit

Cost Per Ton ($)	Project	Cost Per Cubic Yard ($)
69	Socorro	169
59	**Homestake**	**145**
43	Carlsbad	79

RESPEC concludes that Homestake Mine's 2002 cost estimate, escalated to 2007 dollars, is in the range of what can be considered reasonable. Its unit costs are between those of the Carlsbad Project and the Socorro Project, two recently completed excavation projects. The overall cost of the excavation of the Homestake detector chamber can be assumed to be on the order of $30 million. This estimate includes $4 million for the concrete liner and $26 million for excavation, in 2007 dollars. In RESPEC's opinion, Homestake's cost estimate would fall into the Department of Energy (DOE) class of Title I, Preliminary Design, which has an accuracy of ± 20 percent (Title II and Title III estimates are increasingly more accurate). Therefore, the range of cost for the Homestake Project, expressed in 2007 dollars, would be $24 to $36 million.

Homestake Mine's 2002 estimated schedule for the excavation of one chamber allowed a duration of 4 years. At that rate, 110,000 tons of waste rock per year or 440 tons of waste rock per day would be mined, assuming that there are 250 workdays in a year (5 workdays per week). That estimate seems unduly conservative.

What do we need to go further

- $200k for much more detailed design. (quote from RESPEC)

- Plan for Rock coring (towards the North) in Fall 2007. Install Stress sensors into favorable holes.
- Waste rock movement. "DUSEL" should provide a drift to Ross rock dump.
    - Use this drift for all waste rock with a common conveyor belt.
    - Think also about a near surface conveyor belt.
- Common water purification system. Design so that capacity can be added and cost per unit mass is low for the whole lab.
- Ventilation design should include effect on the air flow due to the big detector.

PMTs

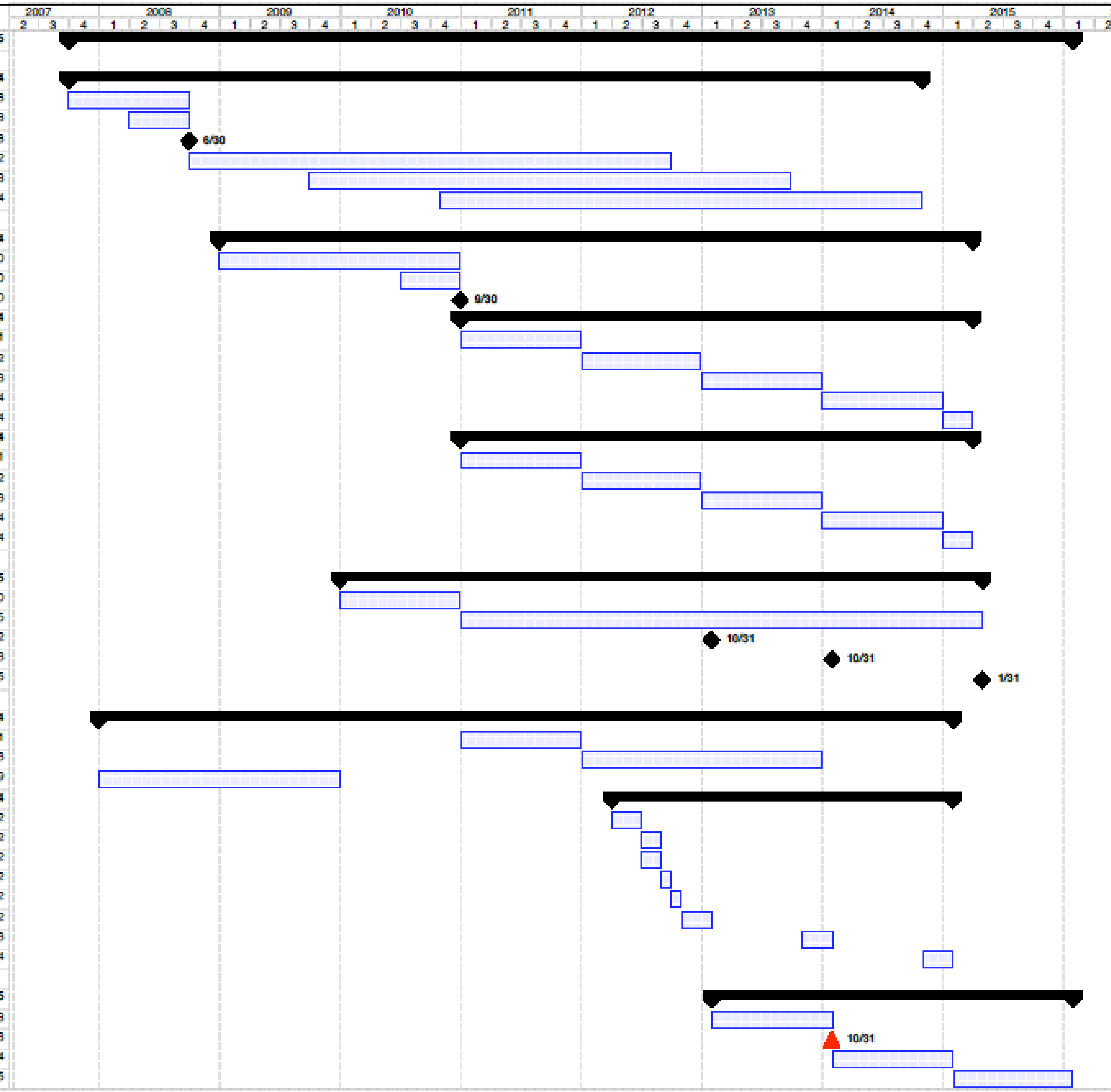
	Cost for one
28 cm dia PMT	\$933
Installation/PM	\$175
Electronics/PM	\$127
Cable/PM	\$86
Total per PMT	\$1317

50000 PMTs per 100 kT tank => 25% coverage

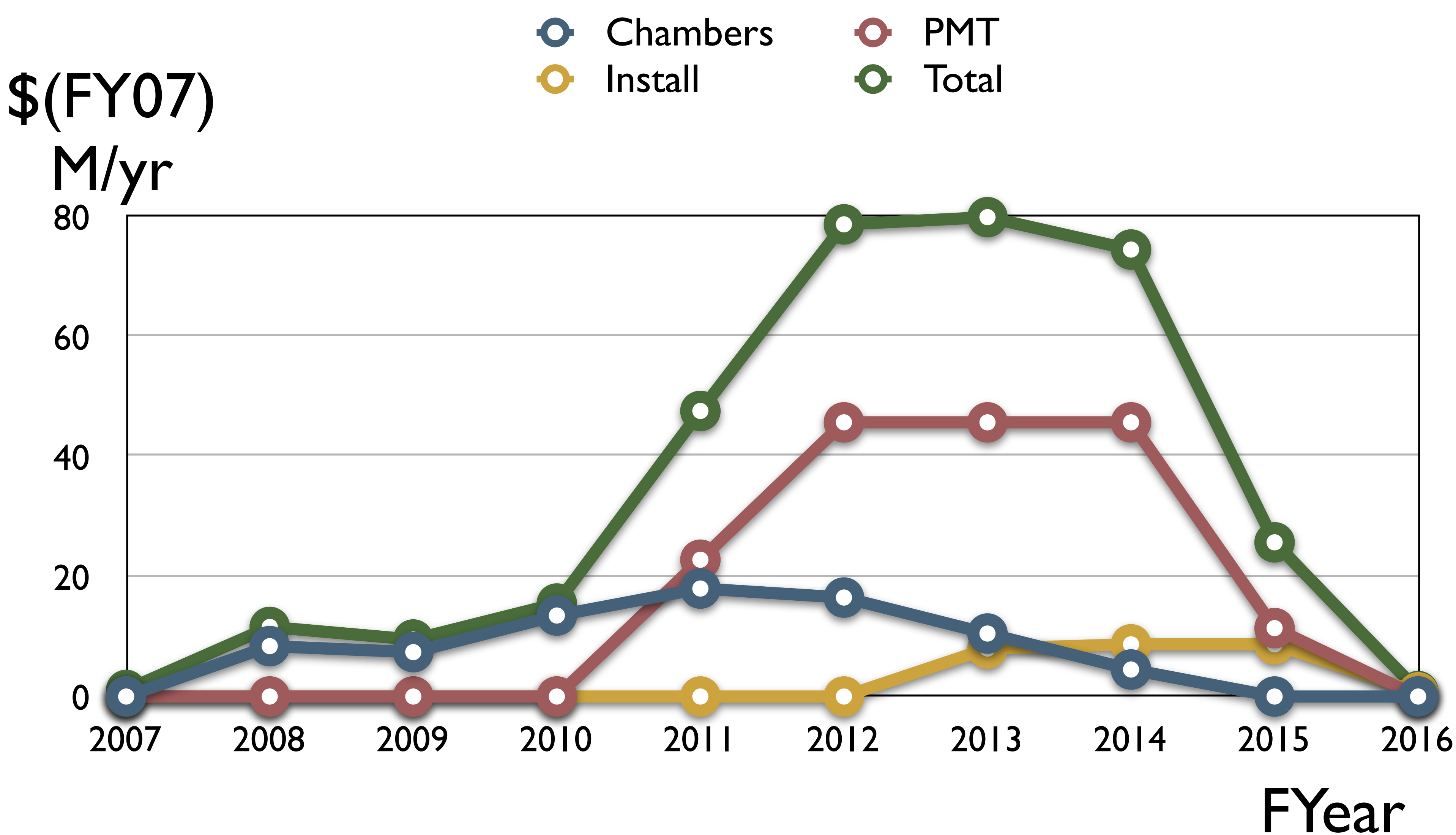
Sanity checks: Auger PMT cost \$629/each for 5000 units with 9 inch diameter. Base cost additional \$175. Other costs have basis with SNO actual costs with adjustments for differences. The installation cost will soon become better with the conceptual engineering subcontract.

Long Baseline Neutrinos + PDK
Schedule No. 2

ID	Task Name	Start	Finish
1	**Long Baseline Neutrinos + PDK**	**7/2/07**	**10/30/15**
2			
3	**Chamber Construction**	**7/2/07**	**7/30/14**
4	Chamber R&D	7/2/07	6/30/08
5	Contract Process	1/1/08	6/30/08
6	Chamber Construction Contract Award	6/30/08	6/30/08
7	Module 1	7/1/08	6/29/12
8	Module 2	7/1/09	6/28/13
9	Module 3	8/2/10	7/30/14
10			
11	**PMs**	**10/1/08**	**12/31/14**
12	PM R&D	10/1/08	9/30/10
13	Contract Process	4/1/10	9/30/10
14	PMs Contract Award	9/30/10	9/30/10
15	**Vendor 1**	**10/1/10**	**12/31/14**
16	Qty 10,000 PMs	10/1/10	9/30/11
17	Qty 20,000 PMs	10/3/11	9/28/12
18	Qyt 20,000 PMs	10/1/12	9/30/13
19	Qty 20,000 PMs	10/1/13	9/30/14
20	Qty 5,000 PMs	10/1/14	12/31/14
21	**Vendor 2**	**10/1/10**	**12/31/14**
22	Qty 10,000 PMs	10/1/10	9/30/11
23	Qty 20,000 PMs	10/3/11	9/28/12
24	Qyt 20,000 PMs	10/1/12	9/30/13
25	Qty 20,000 PMs	10/1/13	9/30/14
26	Qty 5,000 PMs	10/1/14	12/31/14
27			
28	**Testing**	**10/1/09**	**1/31/15**
29	Test Facility	10/1/09	9/30/10
30	Testing of PMs	10/1/10	1/30/15
31	1st Module PMs ready for installation	10/31/12	10/31/12
32	2nd Module PMs ready for installation	10/31/13	10/31/13
33	Final Module PMs ready for installation	1/31/15	1/31/15
34			
35	**Other Equipment**	**10/1/07**	**10/31/14**
36	Calibration Equipment R&D	10/1/10	9/30/11
37	Calibration Equipment	10/3/11	9/30/13
38	Development Labor	10/1/07	9/29/09
39	**Water Purification**	**1/2/12**	**10/31/14**
40	Purchase Order	1/2/12	3/30/12
41	Vendor	4/2/12	5/31/12
42	Shop Conversion	4/2/12	5/31/12
43	Install Water Systems (3 systems)	6/1/12	6/29/12
44	Test Water (to see if suitable)	7/2/12	7/31/12
45	Fill up 1st Chamber	8/1/12	10/31/12
46	Fill up 2nd Chamber	8/1/13	10/31/13
47	Fill up 3rd Chamber	8/1/14	10/31/14
48			
49	**Installation**	**11/1/12**	**10/30/15**
50	Module 1	11/1/12	10/31/13
51	Physics Turn-On	10/31/13	10/31/13
52	Module 2	11/1/13	10/31/14
53	Module 3	11/3/14	10/30/15



Profile


Chambers
PMT
Install
Total
$(FY07)
M/yr
80
60
40
20
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
FYear

PMT R&D

- Issues are: making 150000 tubes in 6 years time, their efficiency, and their pressure performance.
- If PMTs can stand higher pressure, the cavern can be taller => more fiducial volume.
- Have had meetings with Photonis and Hamamatsu: no barrier to PMT production except money.

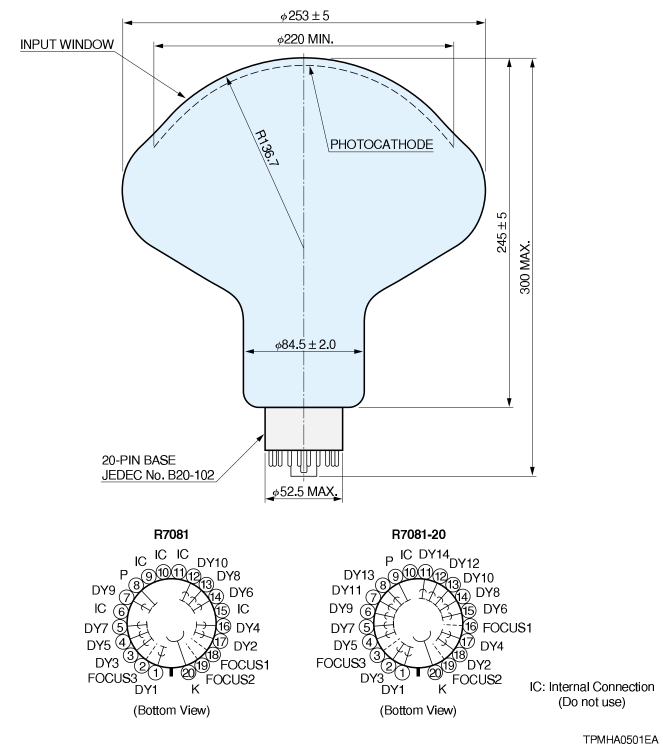
SPECIFICATIONS

Type No.	Cathode Sensitivity: Luminous (2856 K) Min. (µA/lm)	Cathode Sensitivity: Luminous (2856 K) Typ. (µA/lm)	Cathode Sensitivity: Radiant at 420 nm Typ. (mA/W)	Cathode Sensitivity: Blue Sensitivity Index (CS 5-58) Min.	Cathode Sensitivity: Blue Sensitivity Index (CS 5-58) Typ.	Cathode Sensitivity: Quantum Efficiency at 390 nm Typ. (%)	Anode Sensitivity: Luminous (2856 K) Typ. (A/lm)	Anode Sensitivity: Radiant at 420 nm Typ. (A/W)	Anode Sensitivity: Gain Typ.	Anode Sensitivity: Applied Voltage for Typical Gain Typ. (V)
R5912	40	70	72	6.0	9.0	22	700	7.2×10^5	1.0×10^7	1500
R5912-02	40	70	72	6.0	9.0	22	70 000	7.2×10^7	1.0×10^9	1700
R7081	40	80	80	6.0	10.0	25	800	8.0×10^5	1.0×10^7	1500
R7081-20	40	80	80	6.0	10.0	25	80 000	8.0×10^7	1.0×10^9	1700
R8055	35	60	65	5.5	8.0	20	600	6.5×10^5	1.0×10^7	1500
R3600-02	35	60	65	5.5	8.0	20	600	6.5×10^5	1.0×10^7	2000
R7250	35	60	65	5.5	8.0	20	600	6.5×10^5	1.0×10^7	2000

NOTE: Anode characteristics are measured with the voltage distribution ratio shown below.
( ): Measured with the special voltage distribution ratio (Tapered Divider) shown below.

Type No.	Supply Voltage: Anode to Cathode (V)	Supply Voltage: Anode to Last Dynode (V)	Average Anode Current (mA)	Operating Ambient Temperature (°C)	Storage Temperature (°C)	Pressure (MPa)	Direct Interelectrode Capacitances: Anode to Last Dynode (pF)	Direct Interelectrode Capacitances: Anode to All Other Dynodes (pF)
R5912	2000	300	0.1	-30 to +50	-30 to +50	0.7	approx. 3	approx. 7
R5912-02	2000	300	0.1	-30 to +50	-30 to +50	0.7	approx. 3	approx. 7
R7081	2000	300	0.1	-30 to +50	-30 to +50	0.7	approx. 3	approx. 7
R7081-20	2000	300	0.1	-30 to +50	-30 to +50	0.7	approx. 3	approx. 7
R8055	2500	300	0.1	-30 to +50	-30 to +50	0.15	approx. 10	approx. 20
R3600-02	2500	300	0.1	-30 to +50	-30 to +50	0.6	approx. 36	approx. 40
R7250	2500	300	0.1	-30 to +50	-30 to +50	0.6	approx. 10	approx. 15

●R7081, R7081-20

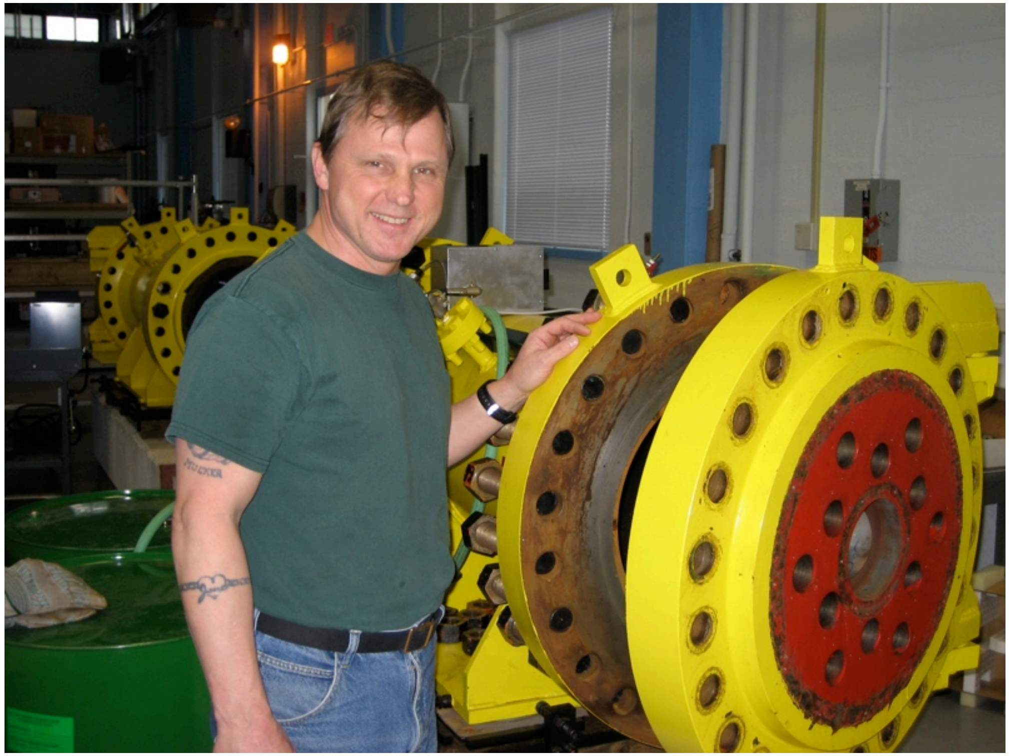


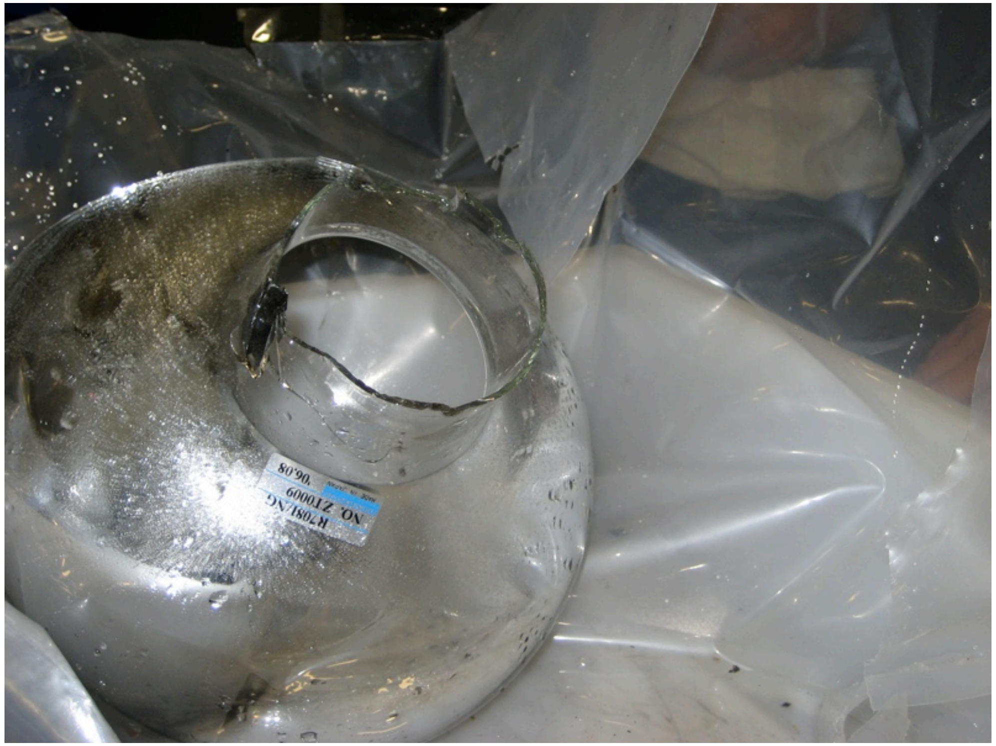
We are focussed on the R7081 tube

It is more efficient than the R3600.

25% *R7081 => 35% *R3600

Pressure testing





Have 32 phototubes from Hamamatsu. Pressure vessel from BNL. Evolving testing protocol.

Hamamatsu rating is ~7atm. Tested this tube until it broke at 148 psi (~10atm)

Switch to Physics

- Accelerator physics: With an intense beam from FNAL.
- Non-accelerator physics:
  - nucleon decay. What is the reach with 300 kT ?
  - low threshold. Can we get to 5 MeV thresholds ?
  - What is the depth needed ?

Summary of depth vs physics/Sobel

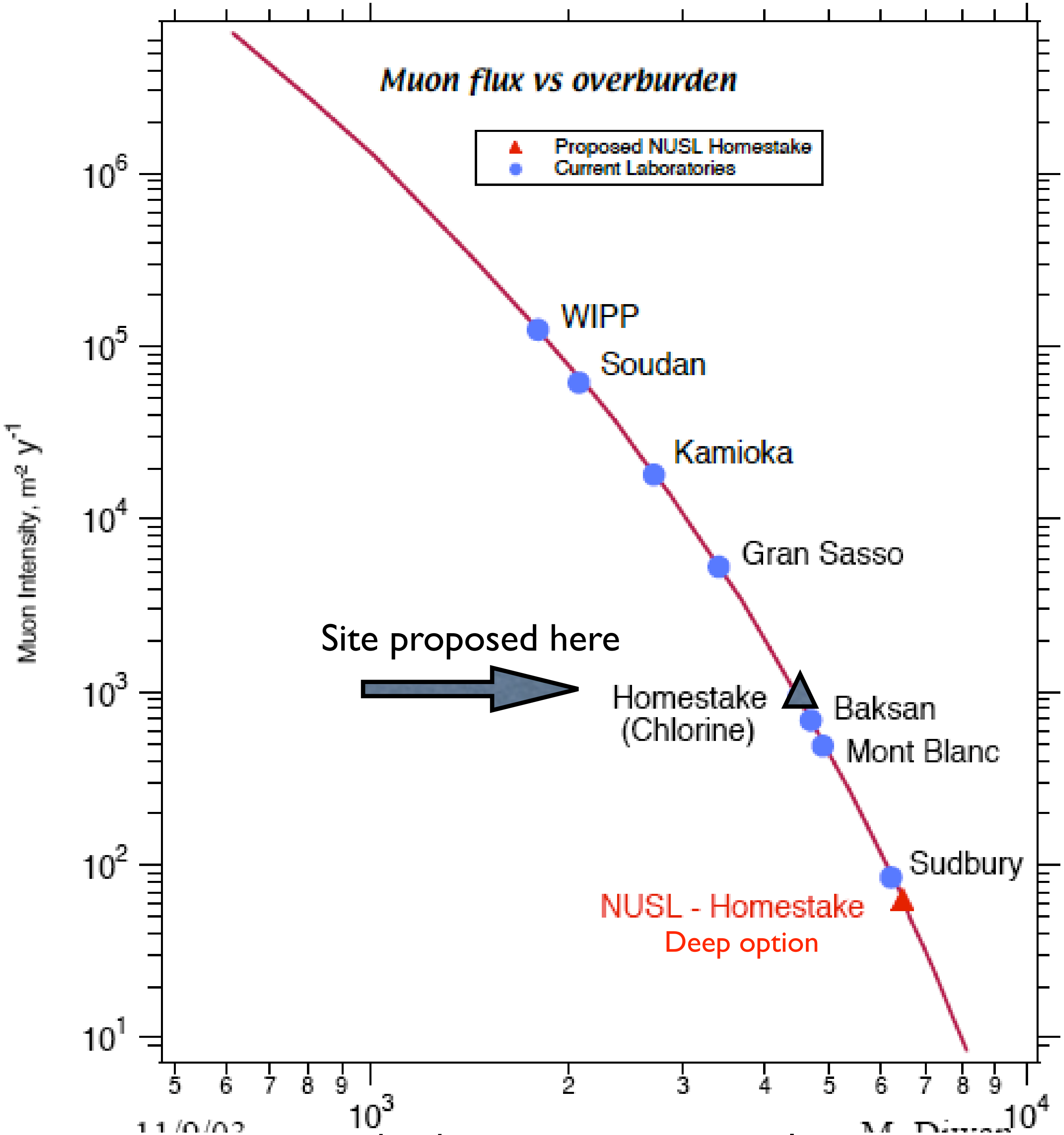
- High energy signals; PDK, atmospheric neutrinos, depth ~ <1600 mwe required.
- Supernova in our galaxy S/B still ~10^3 at 500 mwe. Andromedia S/B ~1 at 1300 mwe.
- Relic neutrinos without Gd needs SK depth – with Gd could possibly go as shallow as ~2000 mwe.
- Reactor neutrinos need ~2000 mwe.
- Solar neutrinos deadtime ~40% at 2360mwe, much less not useful.

4850ft:
100kT
~3M mu/yr

with rate of 1 mu/10 sec => may not need veto-counter

The Beam neutrinos will be obvious with a rate of 100-200/day in 10 mus spills.

No pattern recognition beyond time cut is needed.



depth meters water equivalent

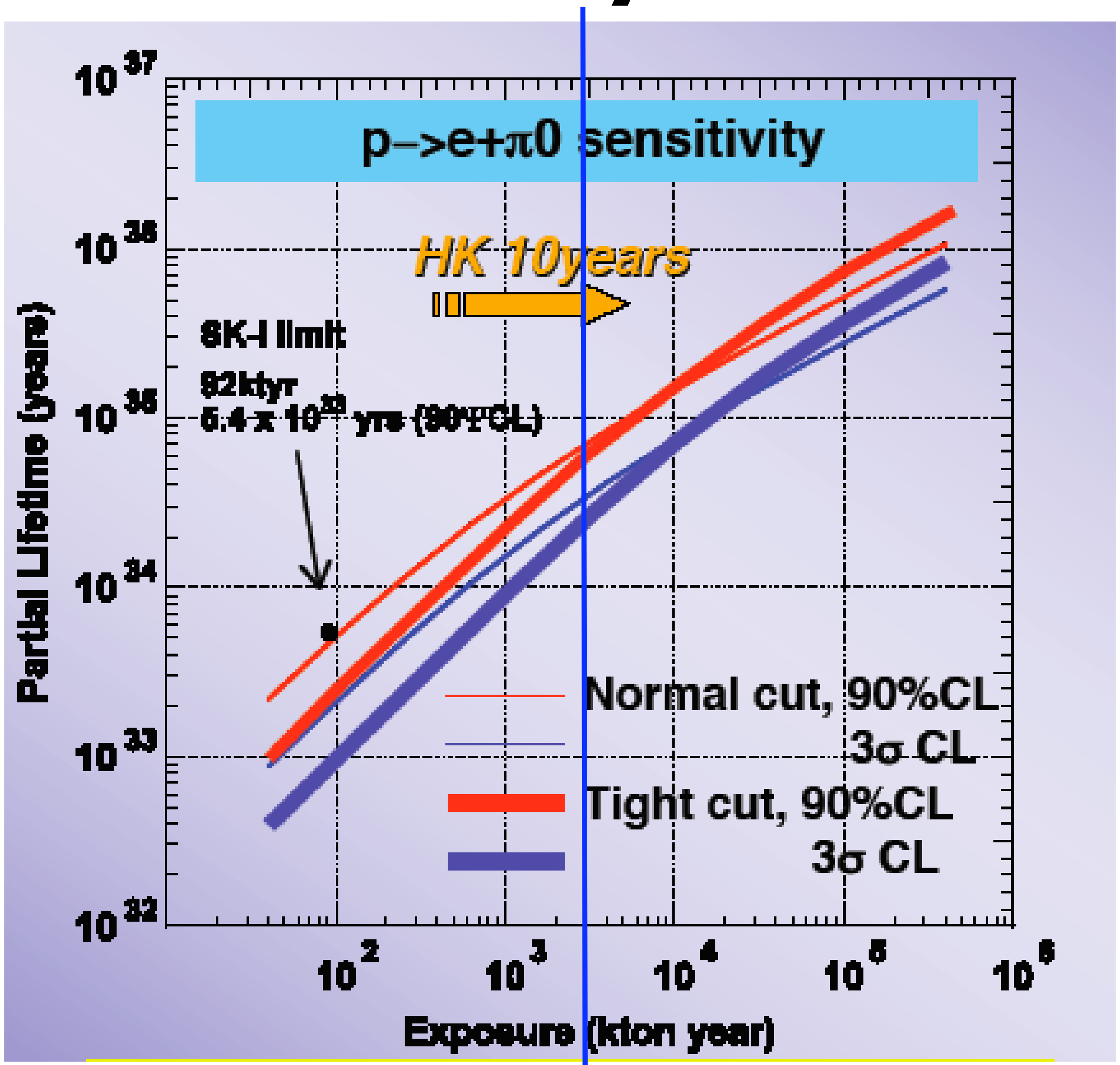
Office of Science
U.S. DEPARTMENT OF ENERGY

BROOKHAVEN NATIONAL LABORATORY

Nucleon decay

- Large body of work by HyperK, and UNO.
- background levels for the positron+Pion mode
  - 3.6/MTon-yr (normal)
  - 0.15/MTon-yr (tight)

(300kT) will hit backg. in <2yrs. It could be important to perform this first step before building bigger. Sensitivity on K-nu mode is about ~8x10^33 yr



Ref: Shiozawa (NNN05) 300kTX10yrs 7X10^34 yrs

Astrophysical Neutrinos
Event rates. (300kT), 3 yrs

- Atmospheric Nus: ~20000 muon, ~10000 electrons. (Ref: Kajita nnn05)
- Solar Nus: >120000 elastic scattering E>5MeV (including Osc.) (Ref: uno)
- Galactic Supernova: ~60000/10 sec in all channels. (~2000 elastic events). (Ref: uno)
- Relic Supernova: (ref: Ando nnn05)
  - flux: ~5 (1.1) /cm2/sec Enu>10 (19) MeV
  - rate: 150 (70) events over backg ~200 !

U.S. Long Baseline ν Study

The Chairs: Sally Dawson (BNL) and Hugh Montgomery (FNAL).

Advisory Committee: Franco Cervelli (INFN) Milind Diwan (BNL); co-leader, Maury Goodman (ANL), Bonnie Fleming (Yale), Karsten Heeger (LBL), Takaaki Kajita (Tokyo), Josh Klein (Texas), Steve Parke (FNAL), Gina Rameika (FNAL); co-leader

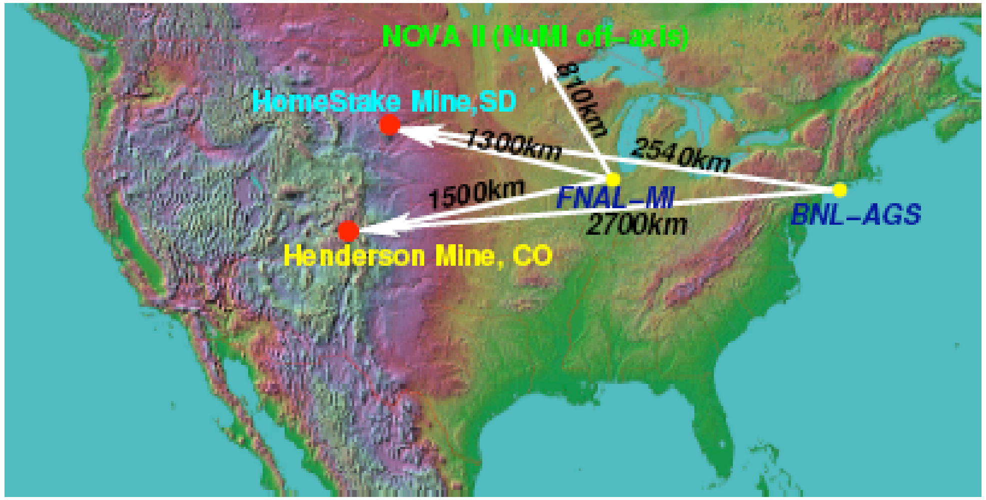
The Charge: Compare the neutrino oscillation physics potential of (report to NuSAG):

1) A broad-band proposal using either an upgraded beam of around 1 MW from the current Fermilab accelerator complex or a future Fermilab Proton Driver (PD) neutrino beam aimed at a DUSEL-based detector (Water Cerenkov and/or Liquid Argon). [this talk]

2) Off-Axis next generation options using a 1-2 MW neutrino beam from Fermilab and a liquid argon detector as a second detector for the NOVA experiment. [Niki Saoulidou's talk]

Status: Documents at http://nwg.phy.bnl.gov/fnal-bnl/

Beam Options/Baselines



The following beam options and baselines are considered:

Off axis beams using the 120 GeV NuMI beamline at FNAL to sites at 810km.

A 28 GeV on-axis Wide-Band Beam (WBB) beam from the BNL AGS to DUSEL sites at 2540 and 2700 km.

A newly designed on-axis ≤ 120 GeV Wide Band Low Energy (WBLE) beam and beamline from the FNAL MI to DUSEL sites at 1300km and 1500km.

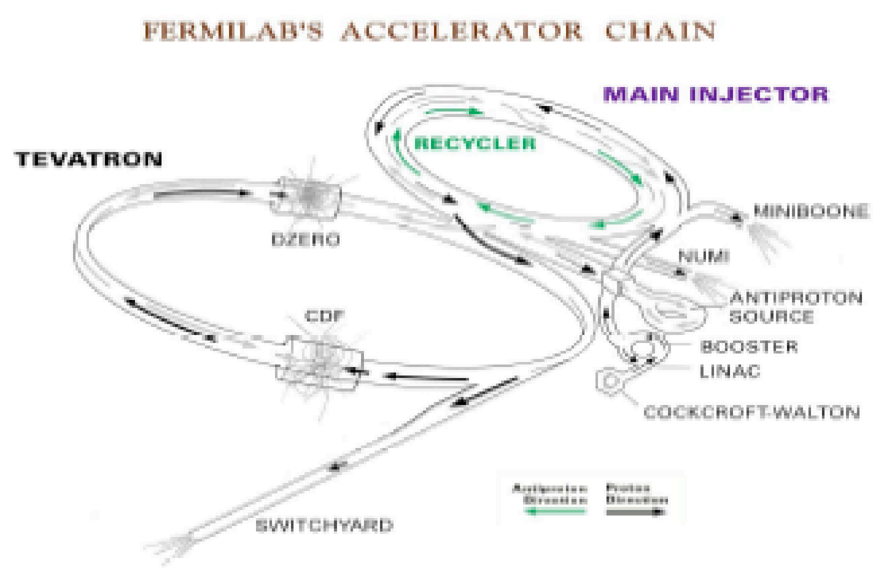
For the current study we will concentrate on beam options from FNAL

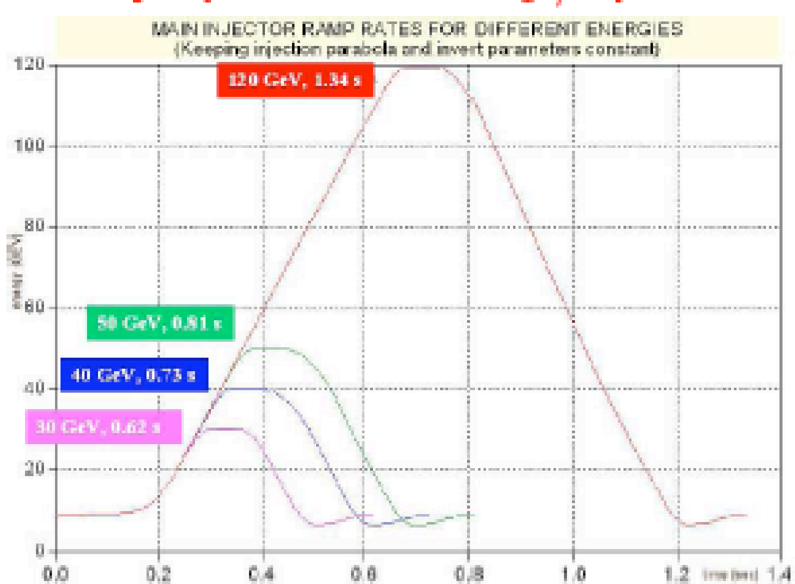
FNAL Beam Specs: E & Power

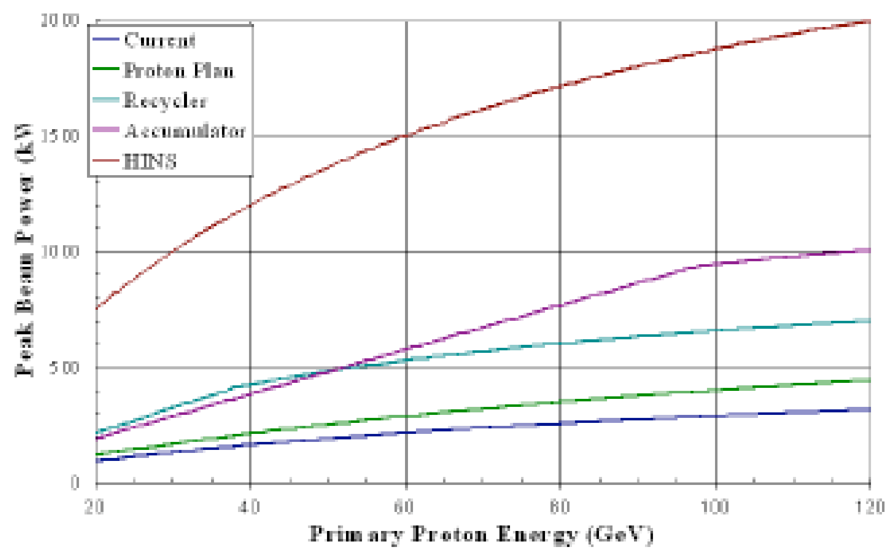
Incremental upgrades possible

(no proton driver):

Use the existing recycler and anti-proton accumulator to store protons from the 8 GeV 15 Hz Booster during the MI cycle then inject to MI bringing intensity up to $6 \times 10^{13} p/$spill.

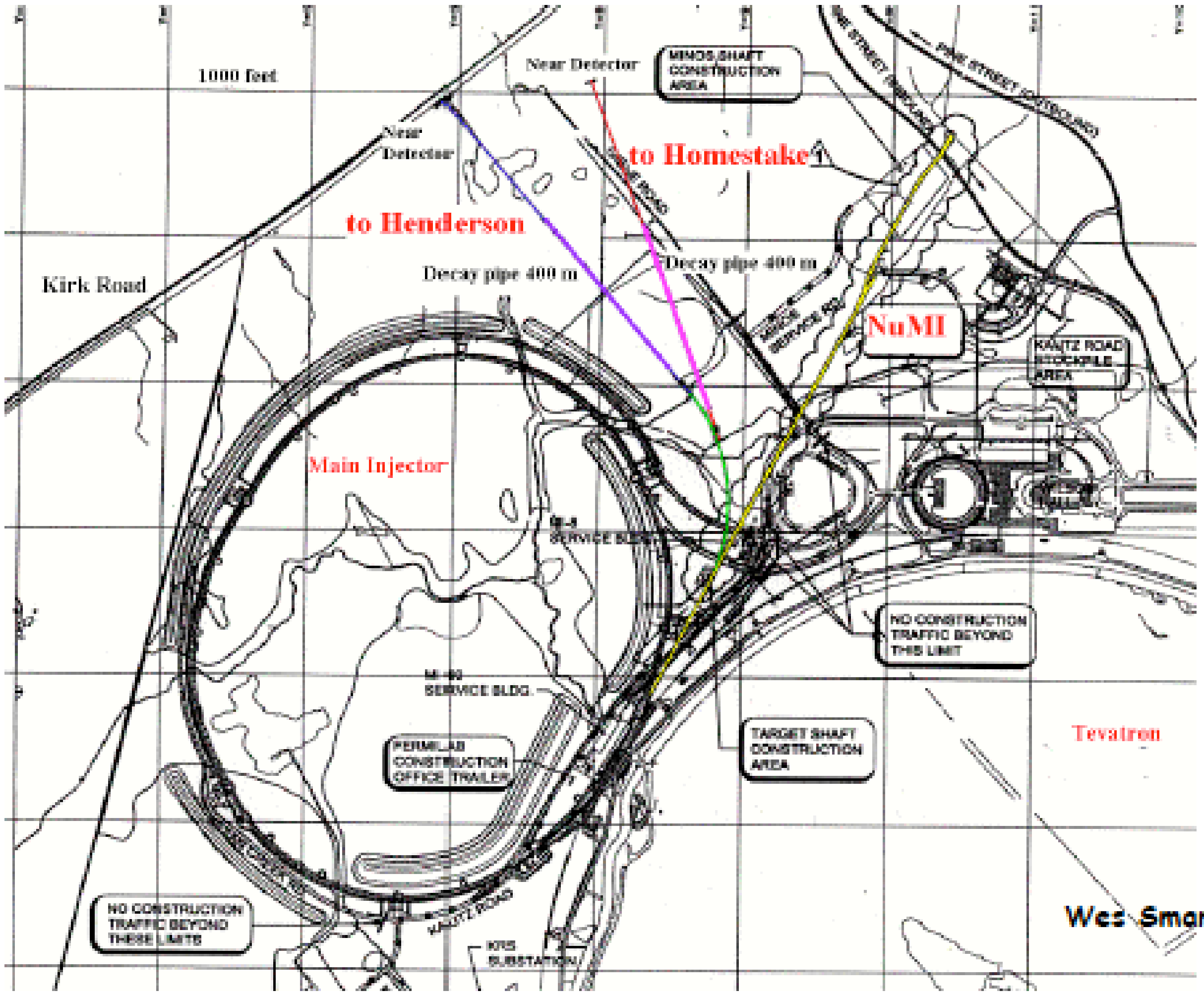






DUSEL Beamline Siting at FNAL

Greg Bock, Dixon Bogert, Wes Smart (FNAL)



Beamlines to DUSEL can accomodate a decay tunnel with $L \leq 400$m on-site

Exploring the possibility of neutrino beams towards a DUSEL site

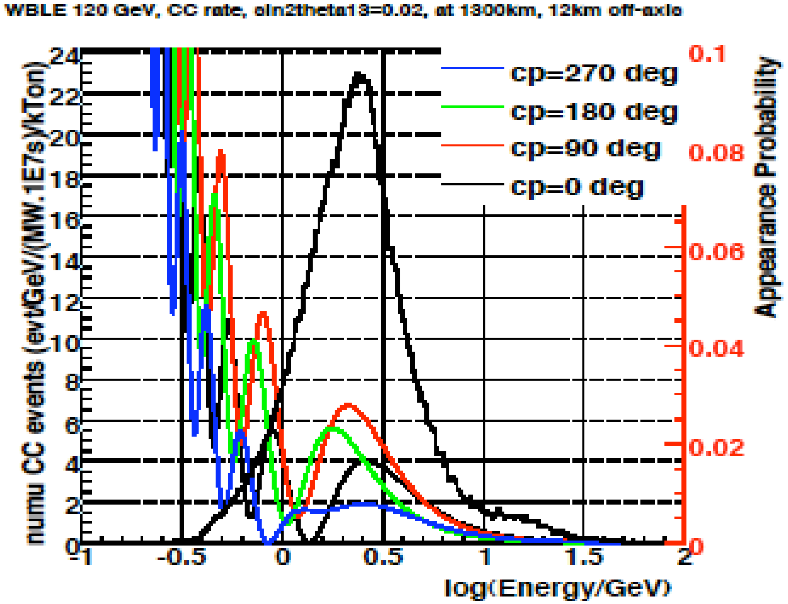
W. Smart

	Latitude	Longitude	Vertical angle from FNAL (deg)	Distance from FNAL (km)
Homestake	44.35	-103.77	-5.84	1289
Henderson	39.76	-105.84	-6.66	1495

- Use of the present extraction out of the Main Injector into the NuMI line
- Construction of an additional tunnel, in the proximity of the Lower Hobbit door in the NuMI line, in order to transport the proton beam to the west direction
- Radius of curvature of this line same as the Main Injector, adequate for up to 120 GeV/c proton beam with conventional magnets
- Assumptions:
  - **a target hall length of ~45 m (same as NuMI for this first layout, probably shorter)**
  - **decay pipe of 400 m (adequate for a low energy beam), we would gain in neutrino flux by increasing the decay pipe radius (> 1 m)**
  - **distance of ~300 m from the end of the decay pipe to a Near Detector (same as NuMI).**

WBLE Beam Design Requirements

The design specifications of a new WBLE beam based at the Fermilab MI are driven by the physics of $\nu_\mu \rightarrow \nu_e$ oscillations:



L = 1300 km

Requirements:

-Maximal possible neutrino fluxes to encompass the 1st and 2nd oscillation nodes, with maxima at 2.4 and 0.8 GeV.

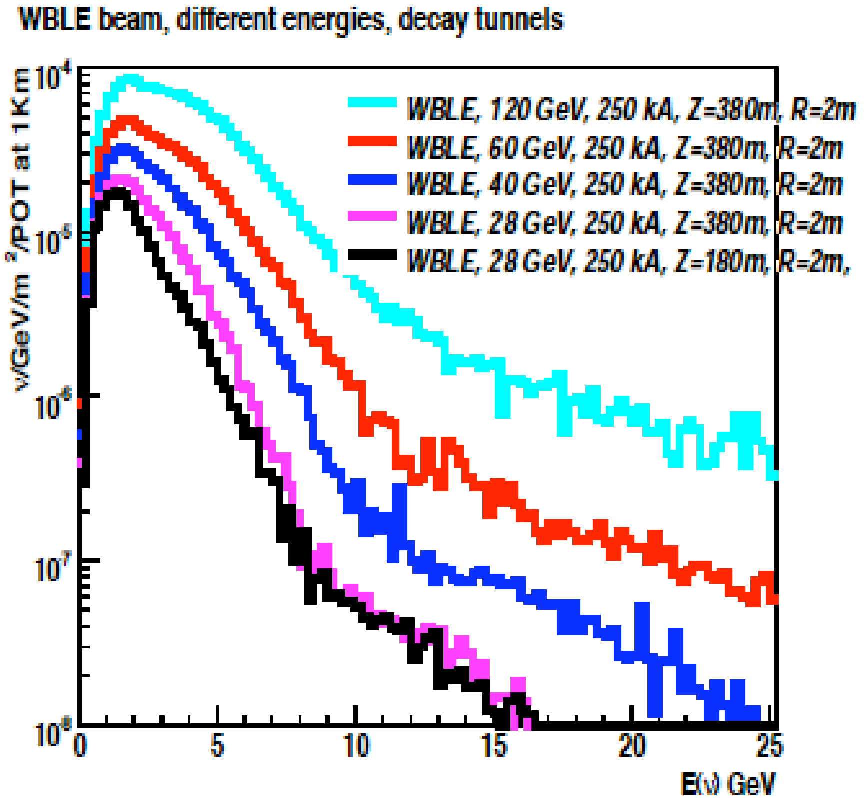
-High purity ν_μ beam with negligible ν_e

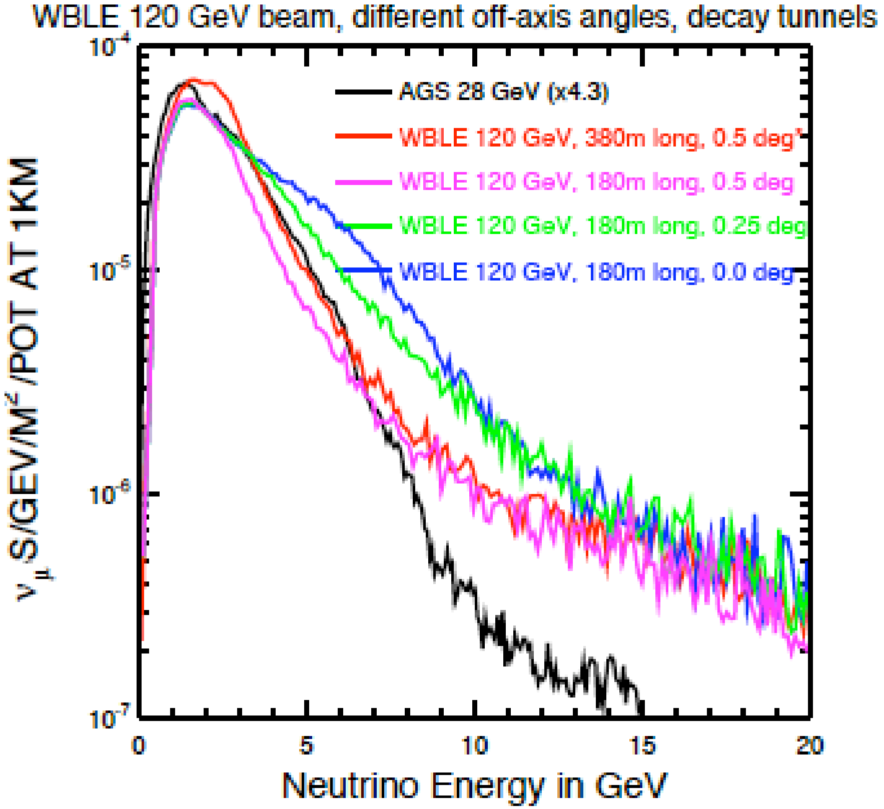
-Minimize the neutral-current feed-down contamination at lower energy, therefore minimizing the flux of neutrinos with energies greater than 5 GeV where there is no sensitivity to the oscillation parameters is highly desirable.

WBLE Beam Spectra for VLBNO

Decay pipe radius chosen to be 2m = the maximum that can be accomodated in FNAL rock with concrete shielding for a MW class beam.

Siting restrictions at FNAL $\Rightarrow$ decay pipe is $\leq$ 400 m in length





GEANT 3.21 simulation of wide-band horns+decay pipe, with FLUKA '05 for target hadro-production.

Based on NuMI simulation which matches observed MINOS event rate to 10% in 0 - 7 GeV range

ν_e Appearance Rates

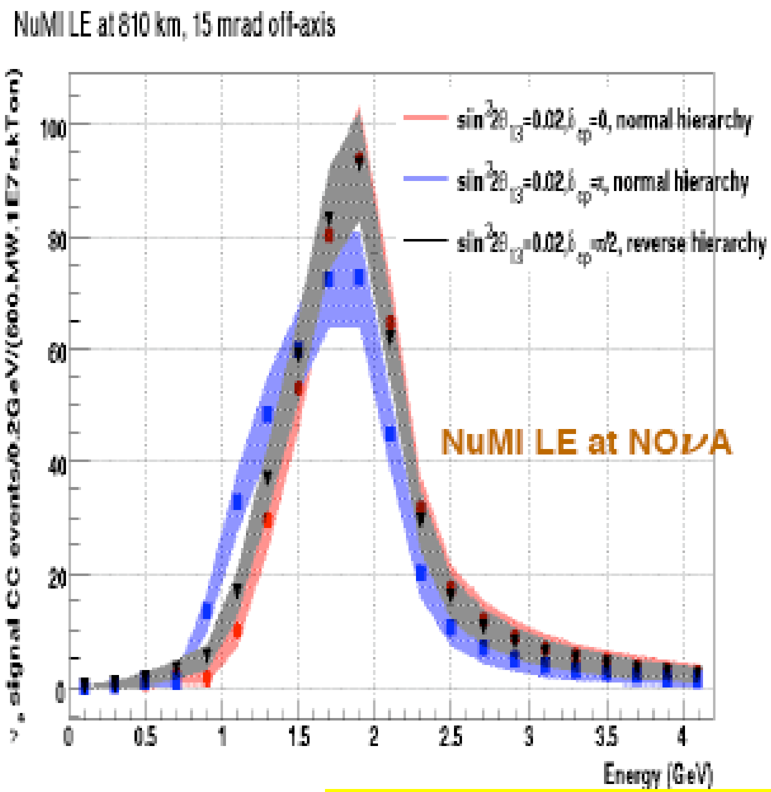
$\Delta m^2_{21,31} = 8.6 \times 10^{-5}, 2.5 \times 10^{-3}$ eV^2, $\sin^2 2\theta_{12,23} = 0.86, 1.0$

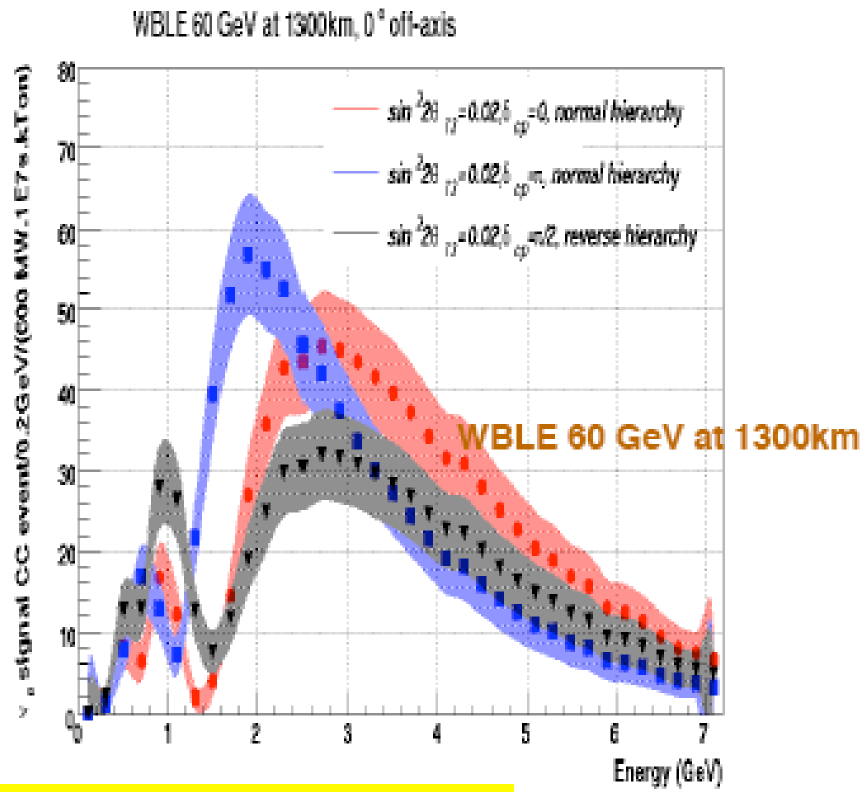
		$\nu_\mu \to \nu_e$ rate				$\bar{\nu}_\mu \to \bar{\nu}_e$ rates			
(sign of Δm^2_{31})	$\sin^2 2\theta_{13}$	δ_{CP} deg.							
		0°	-90°	180°	+90°	0°	-90°	180°	+90°
NuMI LE beam tune at 810km, per 100kT. MW. 10^7s									
15 mRad off-axis (NOνA)		Beam ν_e = 43*				Beam $\bar{\nu}_e$ = 17*			
(+)	0.02	76	108	69	36	20	7.7	17	30
(-)	0.02	46	77	52	21	28	14	28	42
50 mRad off-axis		Beam ν_e = 11*				Beam $\bar{\nu}_e$ = 3.4*			
(+)	0.02	5.7	8.8	5.1	2.2	2.5	1.6	0.7	3.3
(-)	0.02	4.2	8.0	5.7	2.0	2.3	2.2	0.8	3.6
WBLE 120 GeV beam at 1300km, per 100kT. MW. 10^7s									
9 mRad off-axis		Beam ν_e = 47**				Beam $\bar{\nu}_e$ = 17**			
(+/-)	0.0	14	N/A	N/A	N/A	5.0	N/A	N/A	N/A
(+)	0.02	87	134	95	48	20	7.2	15	27
(-)	0.02	39	72	51	19	38	19	33	52

* = 0-3 GeV ** = 0-5 GeV, 1 MW. 10^7s = 5.2×10^{20} POT at 120 GeV

ν_e Appearance Spectra

- $\sin^2 2\theta_{13} = 0.02, \delta_{cp} = 0$, normal hierarchy
- $\sin^2 2\theta_{13} = 0.02, \delta_{cp} = \pi$, normal hierarchy
- $\sin^2 2\theta_{13} = 0.02, \delta_{cp} = -\pi/2$, reverse hierarchy



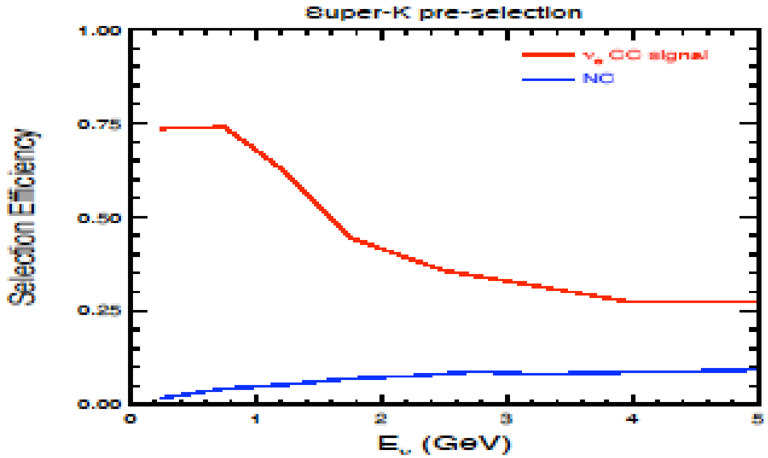


Spectral information = resolves degeneracies

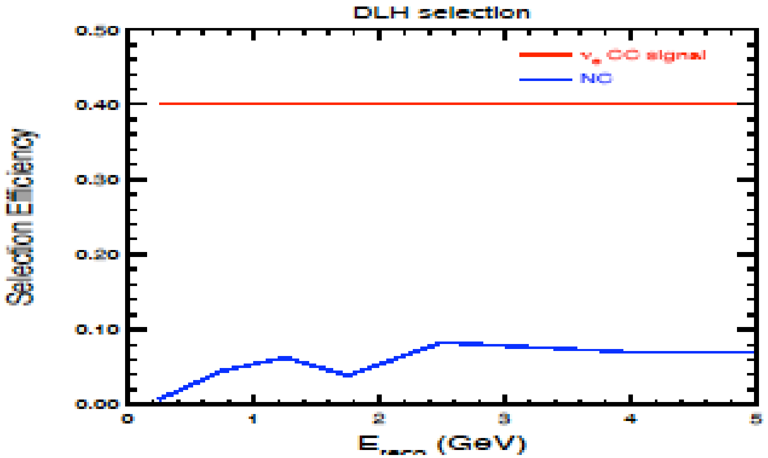
Water Cerenkov Simulation

The ν_{atm} GEANT simulation of SuperKamiokande is used.

An π^0 reconstruction algorithim called "Pattern Of Light Fit" is used as input to a likelihood (DLH) analysis to reconstruct $\pi^0 \rightarrow \gamma\gamma$ by looking for the 2nd ring. Independent studies by Chiaki Yanagisawa for FNAL-DUSEL WBB and Fanny Dufour for T2KK produce similar efficiency for signal and background.



Standard Super-K pre-selection efficiencies



DLH selection efficiencies (Chiaki Y.)

WCe. energy dependent efficiencies and smearing implemented in GLoBeS.

Assumptions in calculations

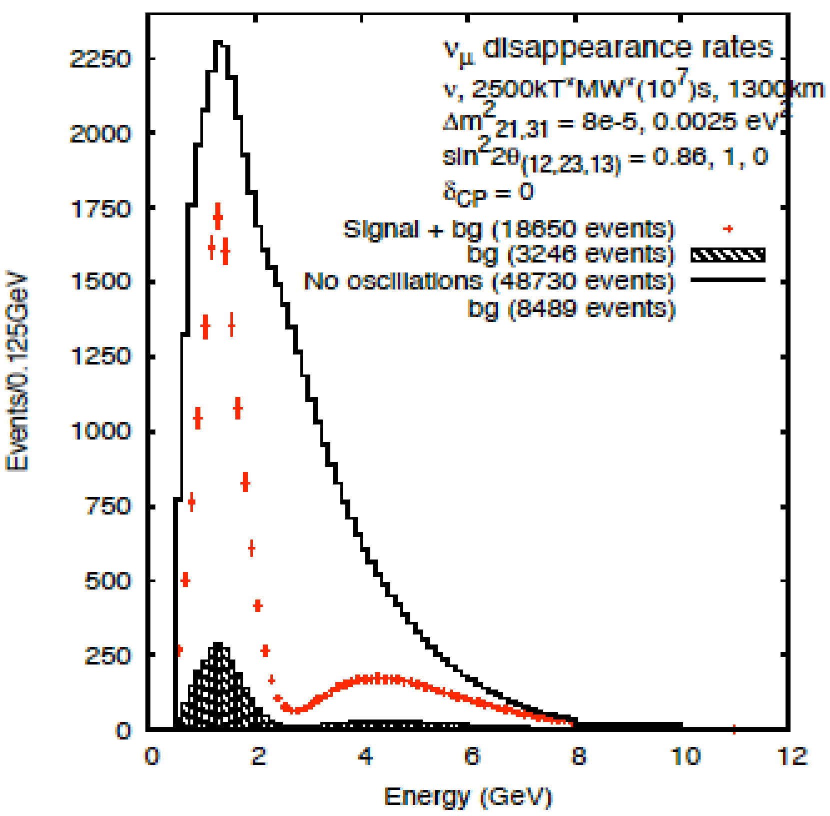
- beam: 120 GeV 0.5 deg
- efficiencies from Yanagisawa for WCh
- for LAR 80% eff for sig. very little NC bkg.
- WCh: 300 kTon fiducial mass, LAR:100kT
- 1300 km (1480 km plots in progress)
- 30e20 protons for each nu and anu

WBLE ν_μ Disappearance Spectra

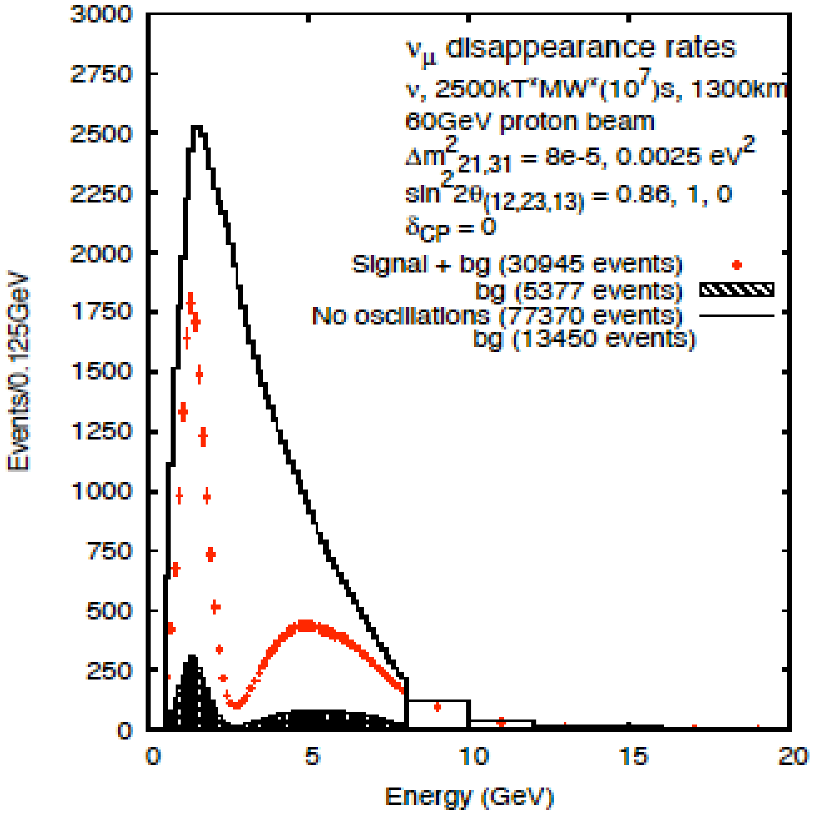
Parameterized WCe. Model in GLoBES.

1300km at 2500 MW.kT.10^7s.

WBB 28 GeV



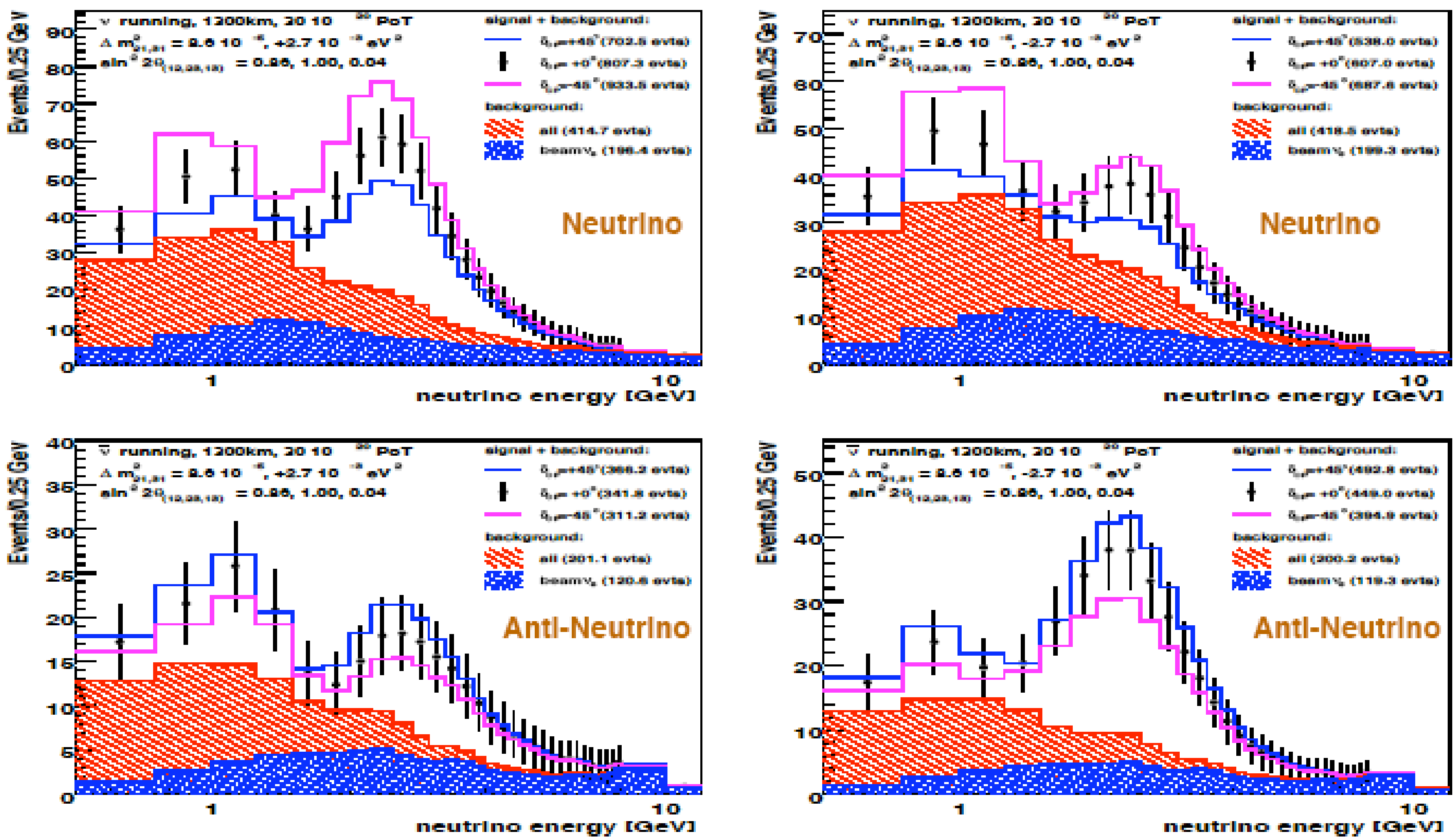
WBLE 60 GeV



GLoBeS ν_e Appearance Spectra

$\sin^2 2\theta_{13} = 0.04$, 300kT WCe. , WBLE 120 GeV, 1300km, 30E20 POT.

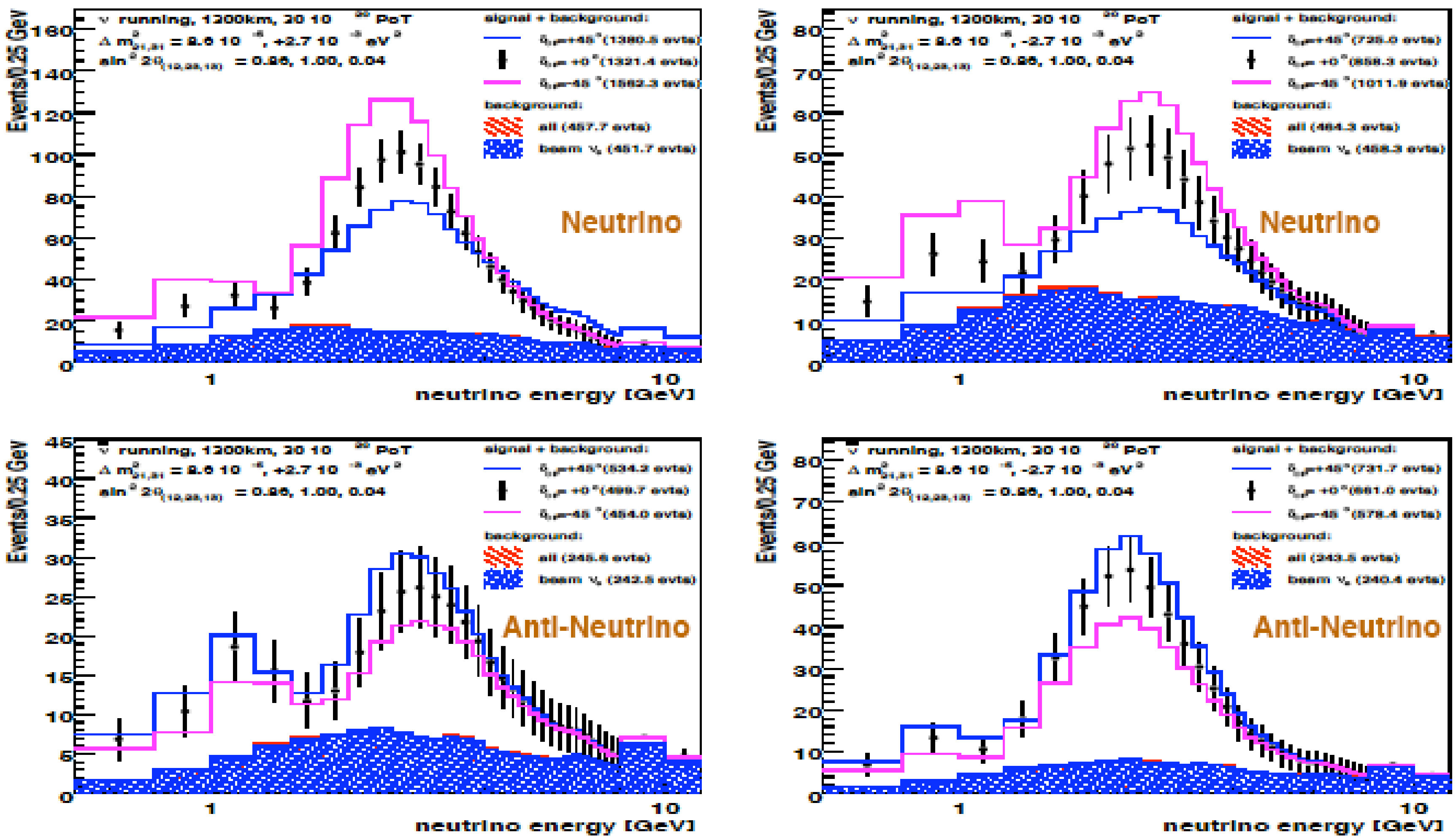
Normal hierarchy (– $\delta_{cp} = -45°$, – $\delta_{cp} = +45°$) Reversed hierarchy



GLoBeS ν_e Appearance Spectra

$\sin^2 2\theta_{13} = 0.04$, **100kT LAr.**, WBLE 120 GeV, 1300km, 30E20 POT.

Normal hierarchy $(-\ \delta_{cp} = -45^\circ,\ -\ \delta_{cp} = +45^\circ)$ Reversed hierarchy



LAr simulation: 80% efficiency for ν_e CC, $\sigma(E)_{QE} = 5\%.\sqrt{(E)}$, $\sigma(E)_{CC} = 20\%.\sqrt{(E)}$

Estimating sensitivities

Matrix parameters used & systematic uncertainties:

-$\Delta m^2_{21,31} = 8.6 \times 10^{-5} (5\%), 2.7 \times 10^{-3}$ eV^2 (uncertainty determined from fit to disappearance mode) -$\sin^2 2\theta_{12,23} = 0.86(5\%), 1.0$(uncertainty determined from fit to disappearance mode) -Matter density (5%) -Background (10%)

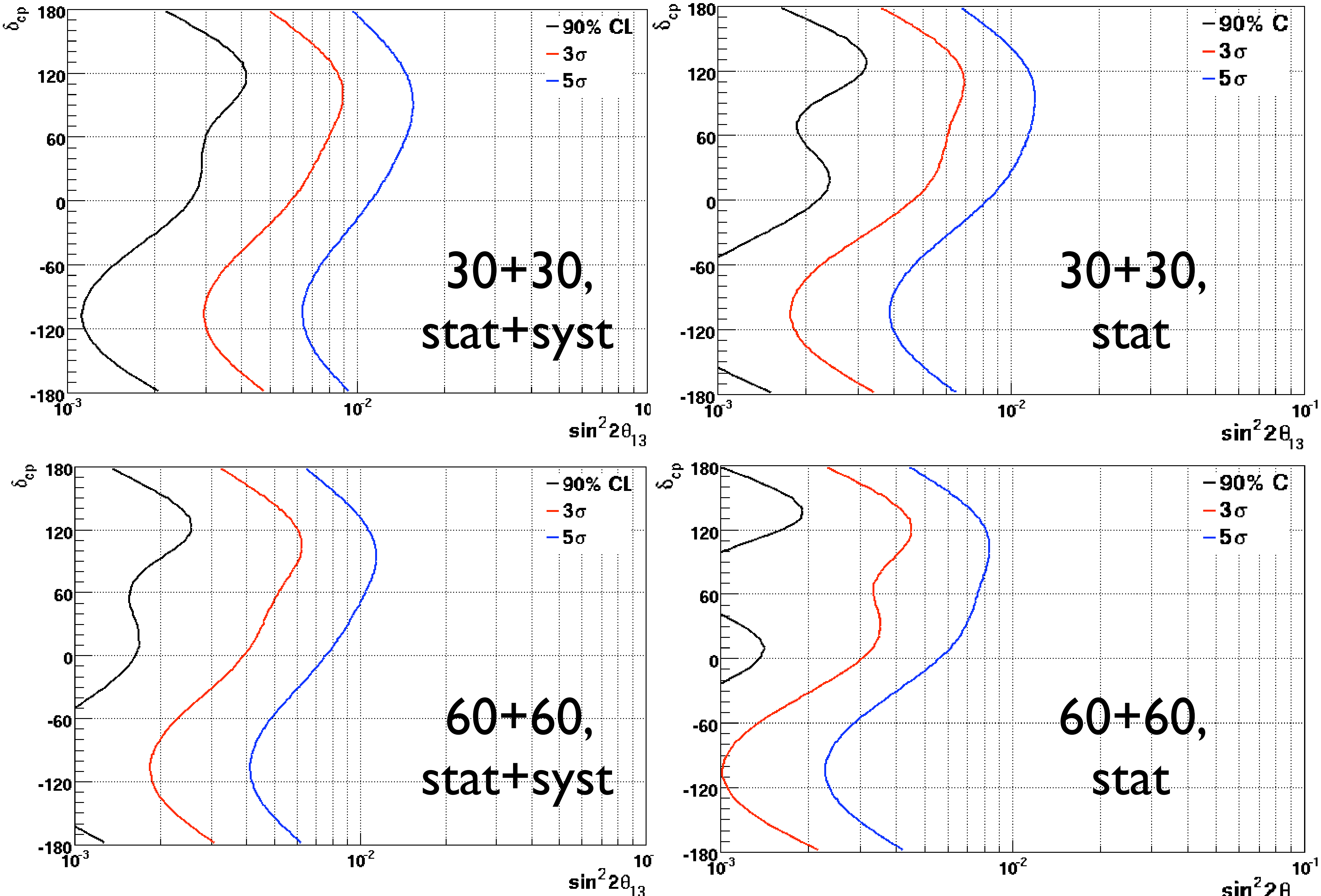
Determining θ_{13} sensitivity: Fit the appearance spectrum generated for various values of θ_{13} and δ_{cp} to the oscillation hypothesis with θ_{13} set to 0.0. Mass hierarchy is fixed.

CP-violation sensitivity: Fit the appearance spectrum to the oscillation hypothesis with $\delta_{cp} = 0$ and π. Take the worst χ^2.
θ_{13} is allowed to float in the fit. Mass hierarchy is fixed.

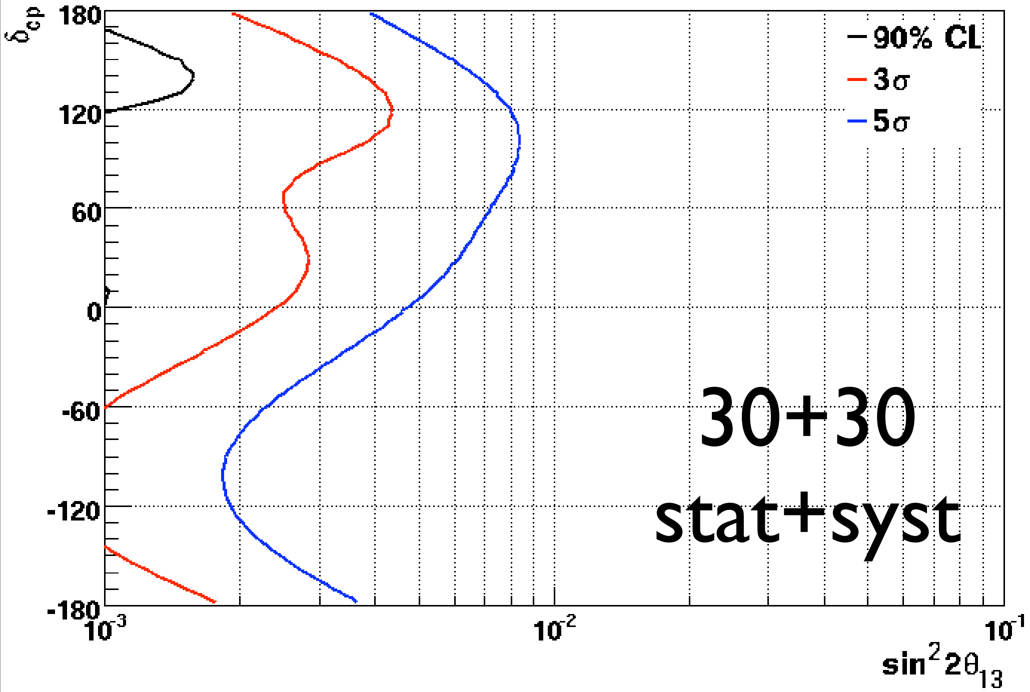
sign(Δm^2_{31}): Fit the appearance spectrum to the oscillation hypothesis with the opposite mass hierarchy.
BOTH θ_{13} and δ_{cp} are allowed to float in the fit.

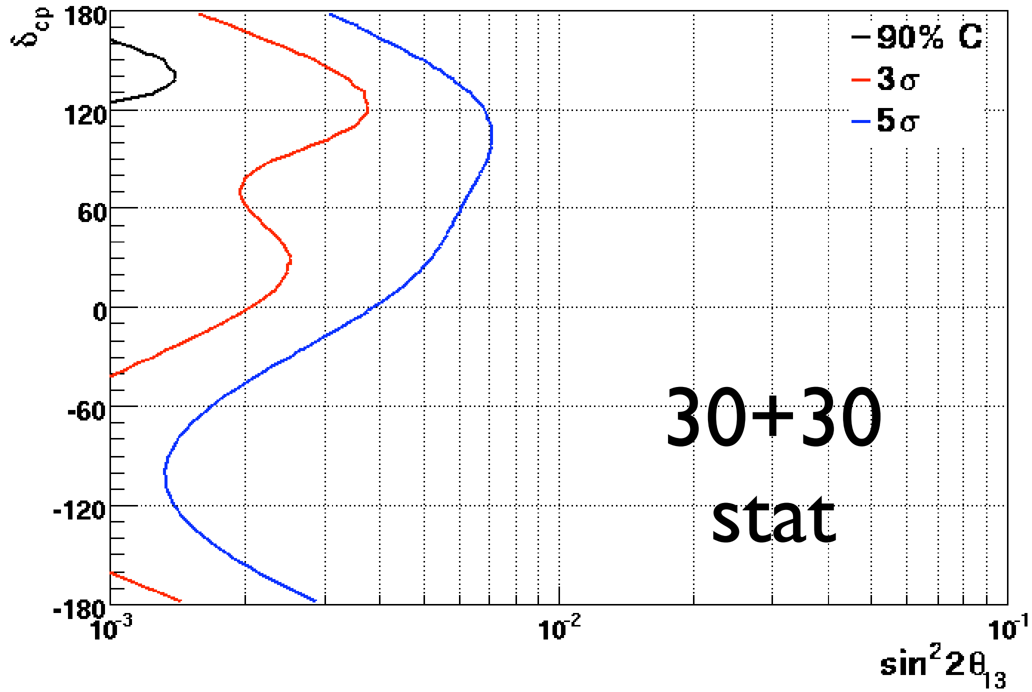
Exposure

- 1.2 MW for 1.7 10^7 sec at 120 GeV = 10.6 e20 POT
- 30e20 => 3 yrs at FNAL
- 60e20 => 6 yrs at FNAL

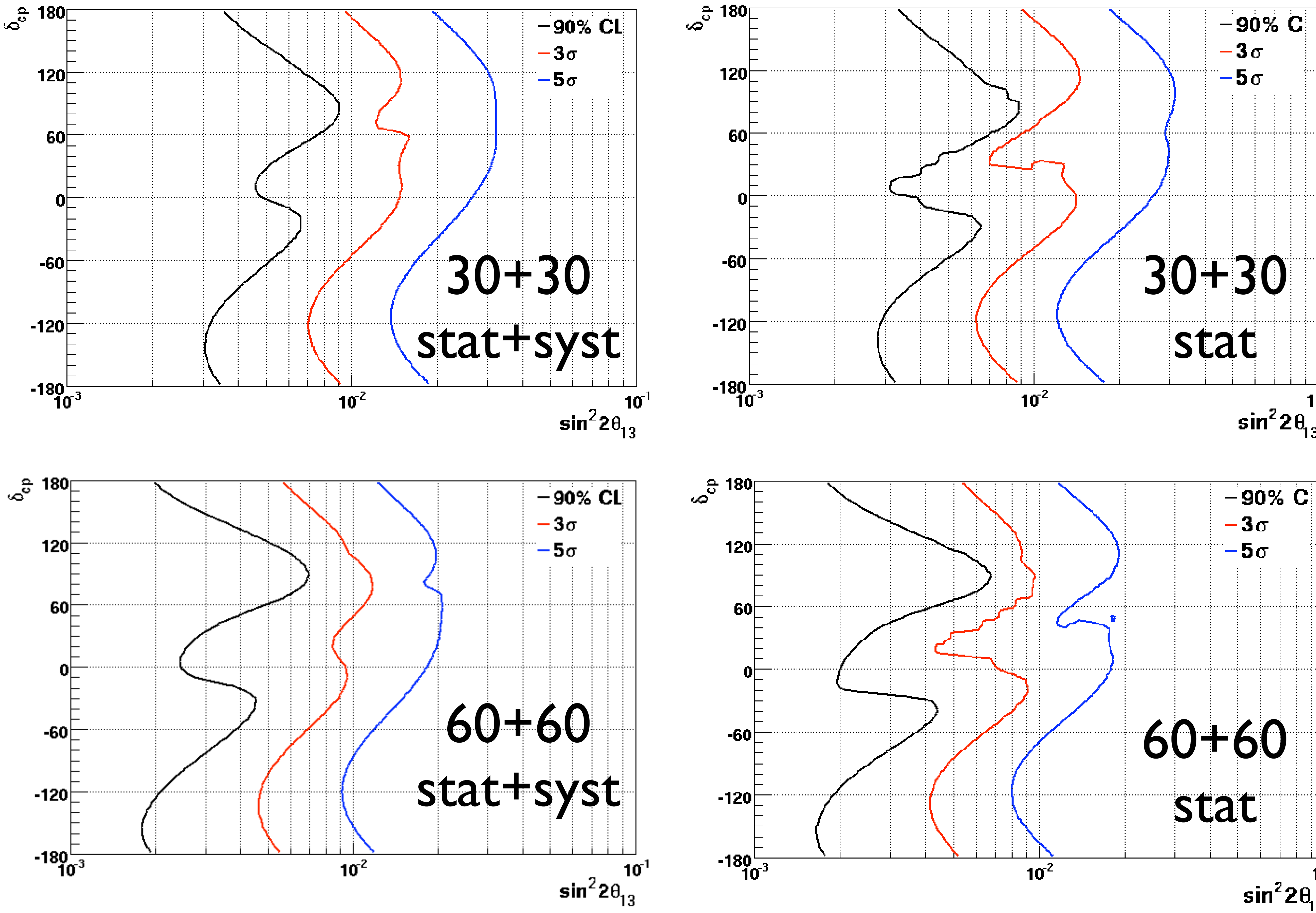


TH13 limit WCh

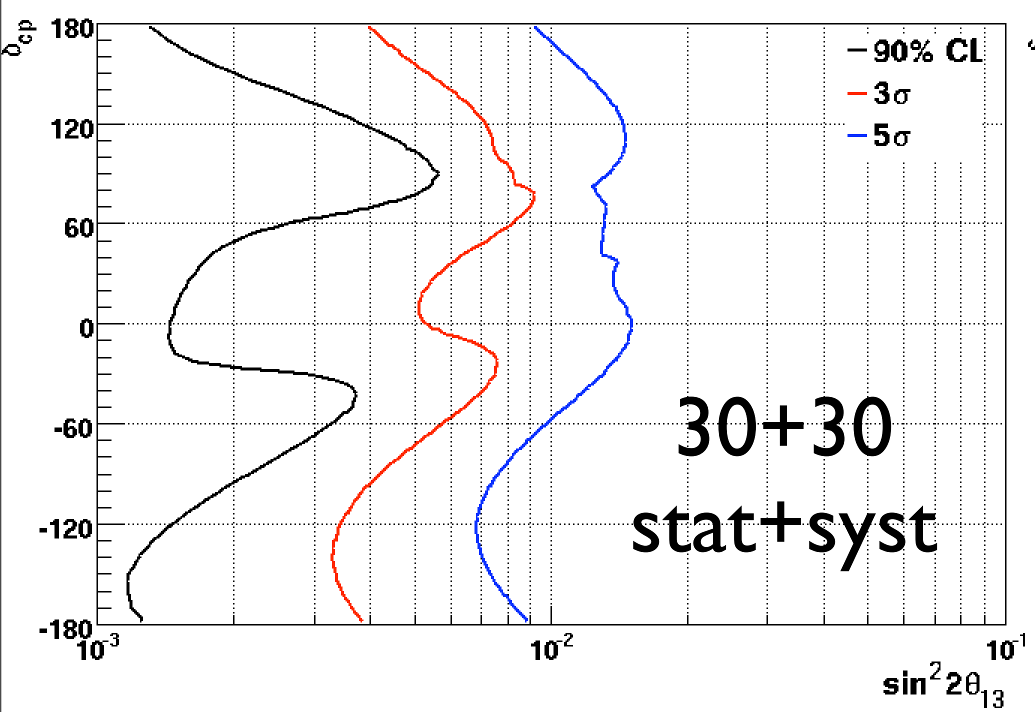


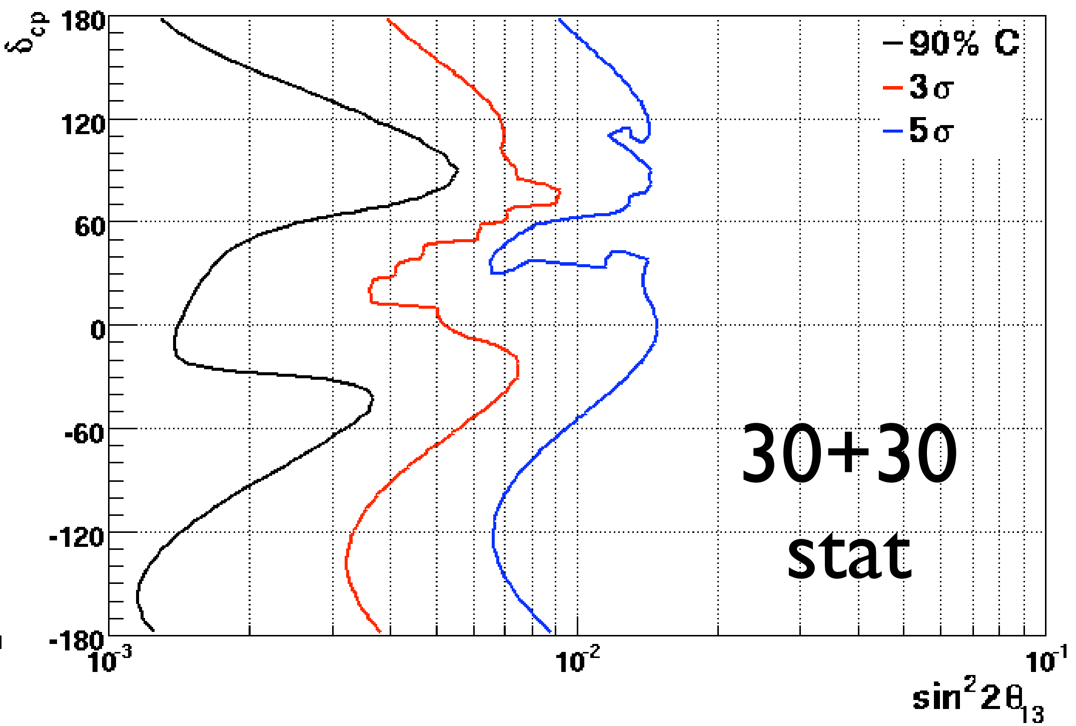


th13 limit LAR

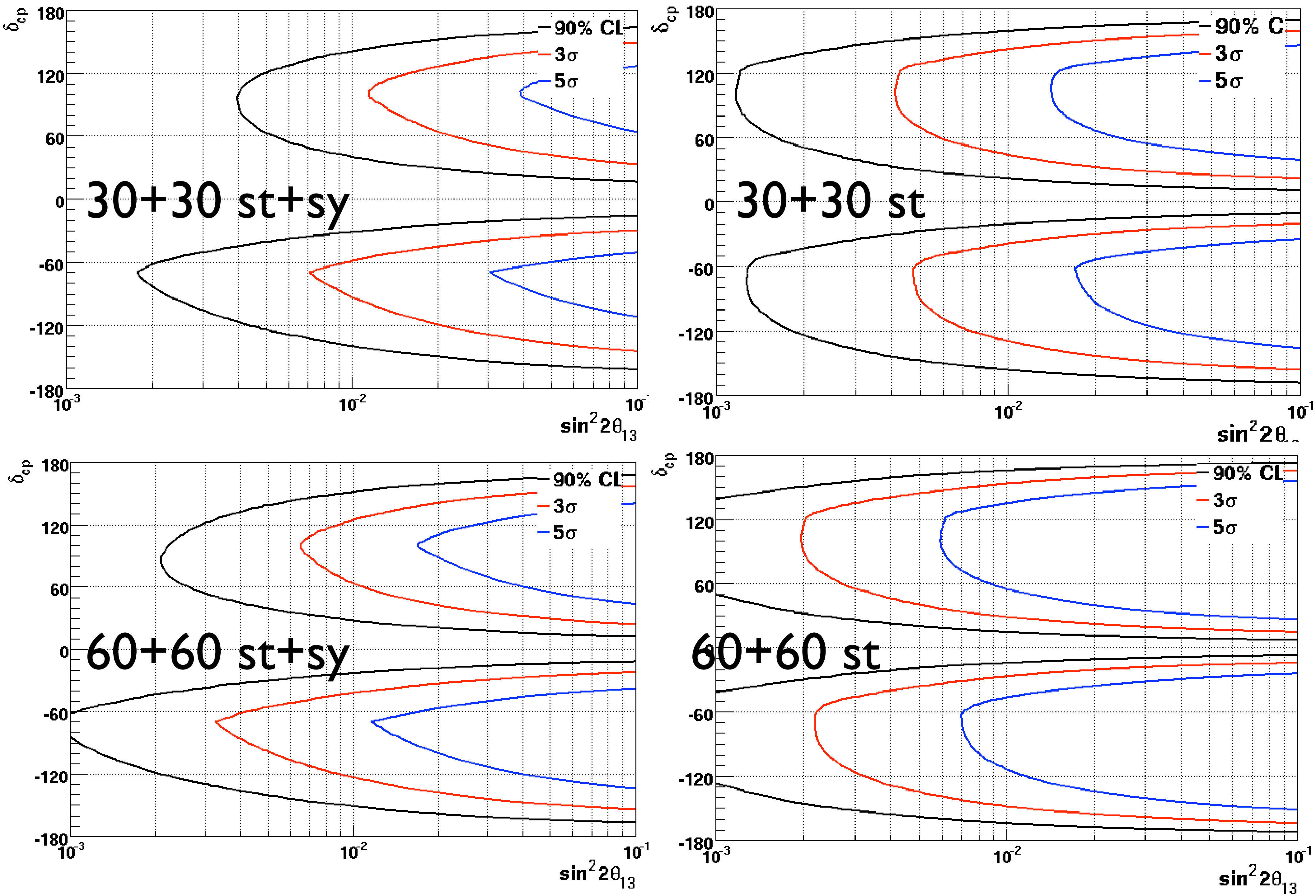


mass hierarchy WCh

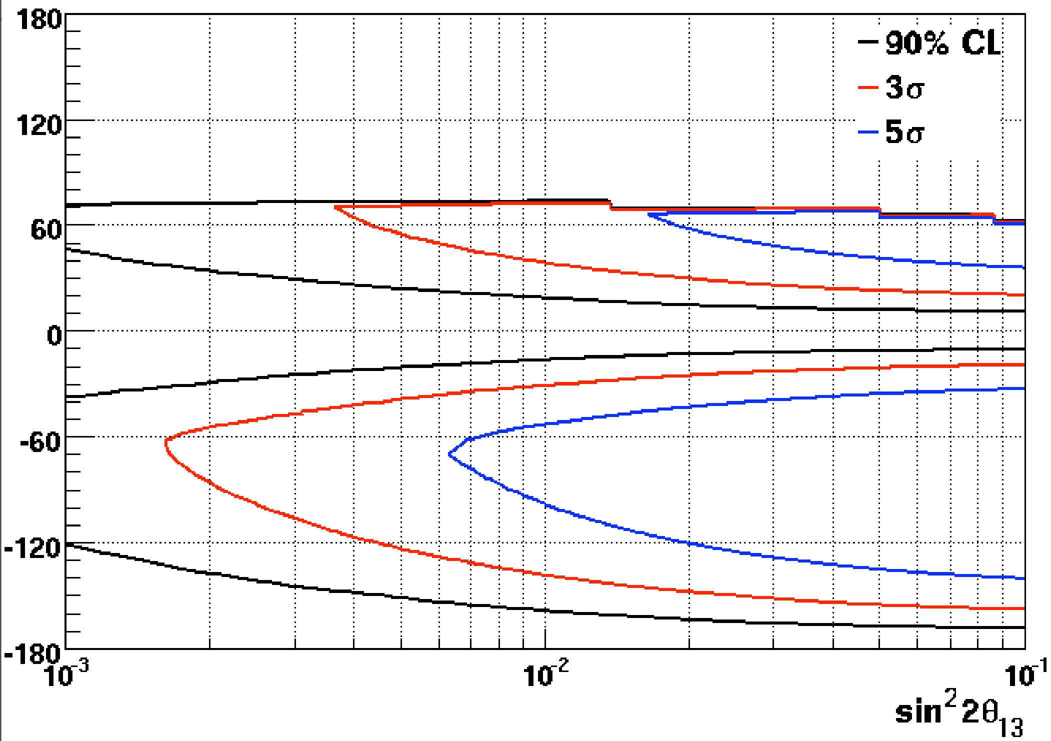




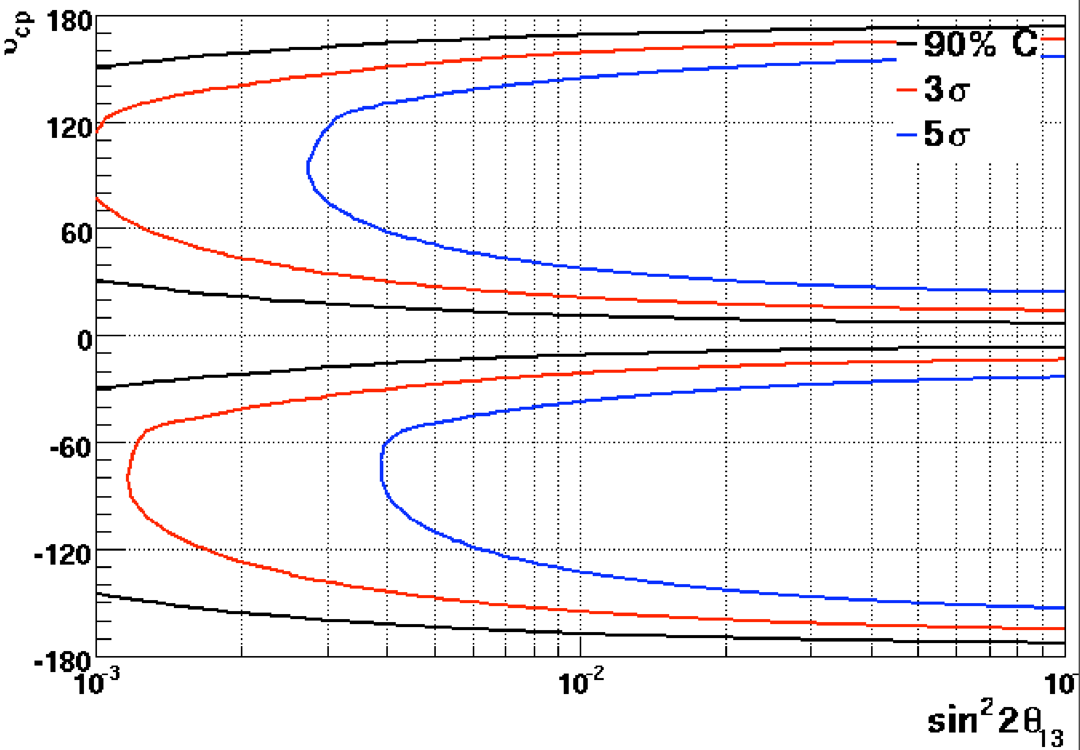
mass hierarchy LAR



CP violation exclusion WCh

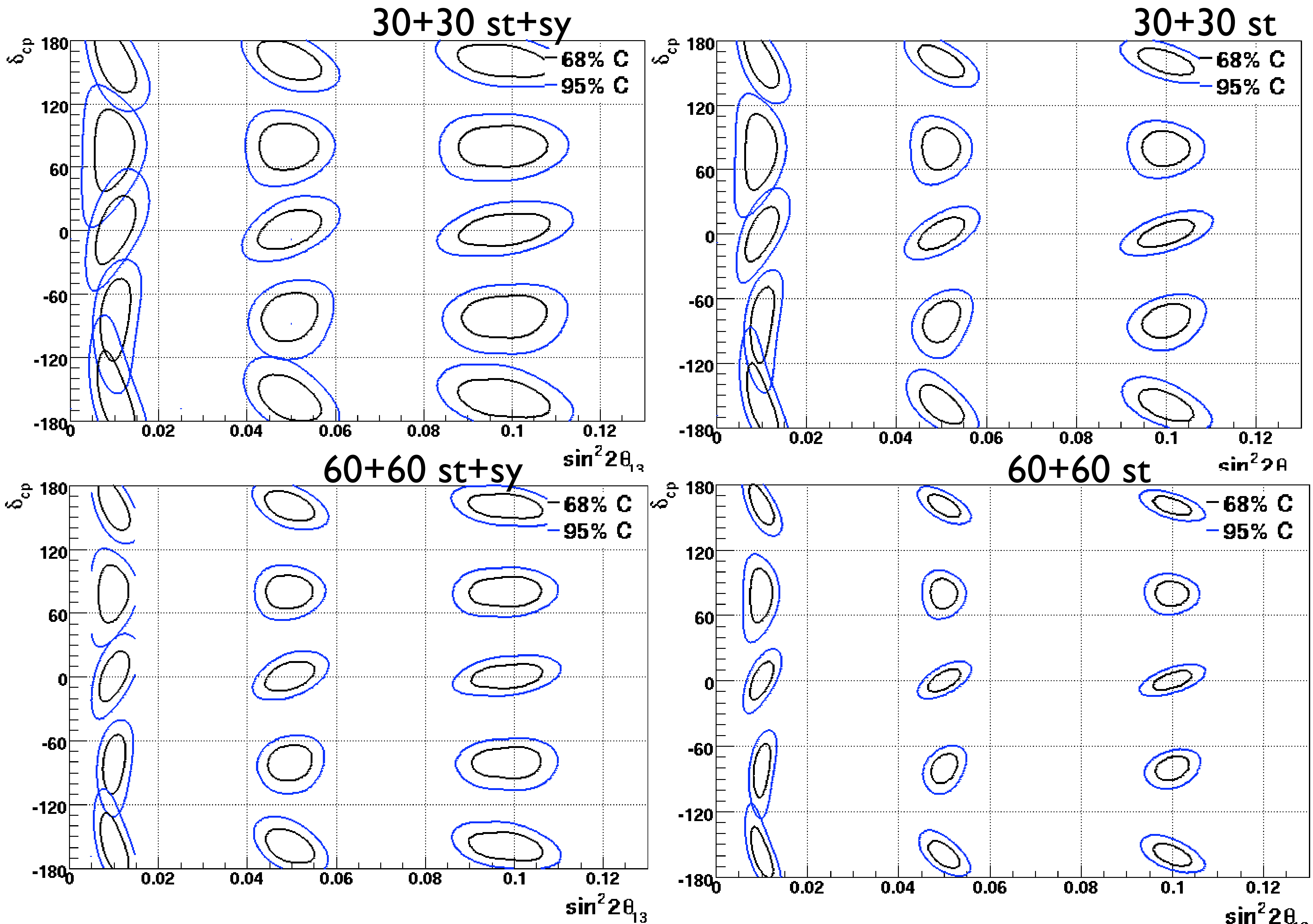


30+30 st+sy

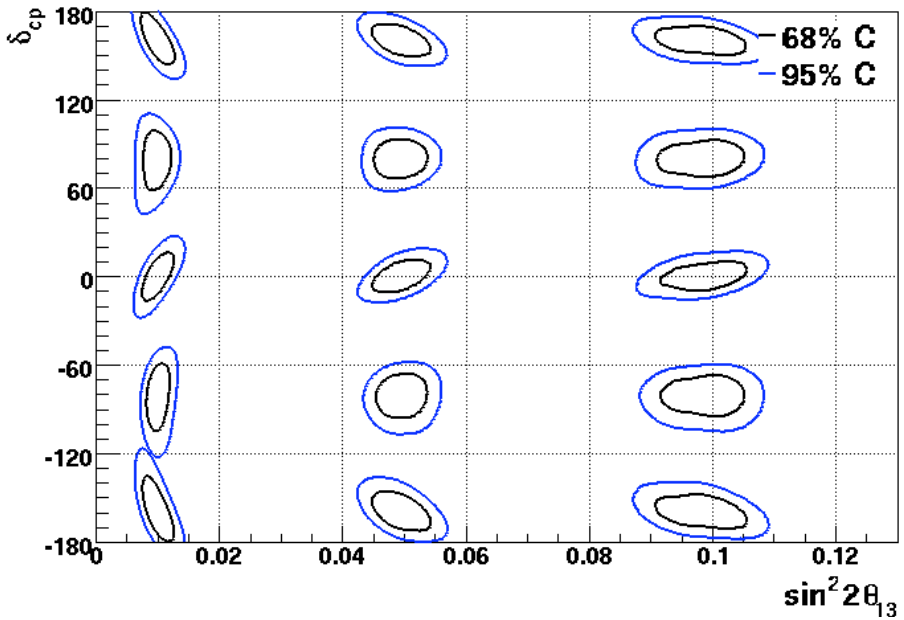


30+30 st

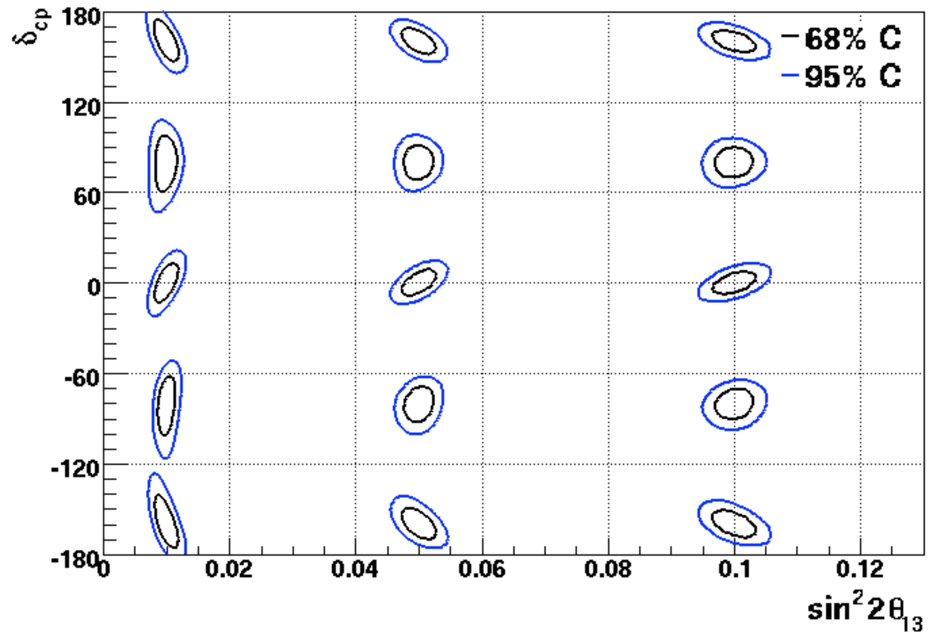
CP exclusion LAR



parameter measurement WCh



30+30 st+sy



30+30 st

parameter measurement LAR

Summary

- I reviewed the physics considerations and technical progress for a large detector at Homestake program.
- A powerful and unique facility is possible if combined with a new MW class proton machine. Such a facility in the US remains well-motivated and possible at FNAL.
- There are two choices for the accelerator program: NuMI based with off-axis surface detectors or DUSEL based with underground detectors that could carry out nucleon decay and other high priority science.
- A very large detector ~100 kT efficient mass is needed to carry out the program no matter where.
- A new joint laboratory (FNAL/BNL)study has been evaluating these and has mostly completed the work.

Homestake coordination issues

- What confidence level can be applied to the cost estimate ?
  - Who pays for exploratory work ? Site investigation 1-3% of total cost.
  - Exploratory galleries (~1%)
  - Cavern instrumentation (~1%) monitoring for 50yrs.
  - Mobilization and demobilization (extra overhead).
  - Who pays for the rock removal and disposal ?
  - Who pays for water consumed in excavation ?
  - What is the contingency for civil construction ? 30%? 50%?
  - What about the DOE, ~22% charge for architeture and engineering (AECM) ?
  - What overheads to be included ? For construction and for operation. Who pays for additional use of hoists, elevators and ventilation ?
  - What is the appropriate labor charge for South Dakota ?

What do we need to go further

- $200k for much more detailed design. (quote from RESPEC)
- Plan for Rock coring (towards the North) in Fall 2007. Install Stress sensors into favorable holes.
- Waste rock movement. "DUSEL" should provide a drift to Ross rock dump.
    - Use this drift for all waste rock with a common conveyor belt.
    - Think also about a near surface conveyor belt.
- Common water purification system. Design so that capacity can be added and cost per unit mass is low for the whole lab.
- Ventilation design should include effect on the air flow due to the big detector.